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Executive Leadership

Assessing Decision Making in Dynamic, High-Risk Environments

To Enhance Amarillo Fire Department Safety

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed:_____

Abstract

The issue examined was the fire service's lack of understanding about firefighter decision-making during dangerous situations. This research assessed the decision-making processes of people in complex scenarios. Descriptive methodology was used to determine the components of decision-making, compare decision-making between firefighters and others, and the impact decisions have on firefighter casualties. The procedures included research questions, literature review, interviews, and a survey. The results were a description of how decisions are made, the similarity between decision-making of firefighters and those in other domains, and that decision-making does affect firefighter casualties. The recommendations were to develop a mentoring program, to create a situational awareness course, to adopt a risk assessment model, and to share the results with mutual aid departments.

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Firefighters are consistently subjected to dangers seldom faced by others. Few people are expected to work in a building being destroyed at an unknown rate while making life-or-death decisions in zero-visibility smoke conditions and extreme temperatures. However, the firefighting profession is different due to the nature of the operational environment, not because firefighters are unique in being subjected to sudden, life-threatening emergencies.

There are an endless number of scenarios that may require an individual to rapidly evaluate an emergency situation and react appropriately. A civilian may be endangered by circumstances beyond their control: an office worker, for example, that just experienced an earthquake that has destroyed the building where she works. The person involved may be a highly trained member of an inherently dangerous profession: for instance, a police officer searching a school to stop a gunman or a miner trapped by an underground explosion. Civilian or professional, the officer worker, the police officer, or the miner will have to function in a setting that is dangerous and dynamic. They must immediately assess the threat and rapidly make decisions that will, hopefully, lead to survival.

Experts in the field of human psychology are attempting to explain how individuals gather information and identify threats in order to make decisions in emergency situations. A witness statement from the investigation into *The Station Nightclub Fire* in West Warrick, Rhode Island (Grosshandler, Bryner, Madrzykowski, & Kuntz, 2005, June) illustrates the need to understand human behavior in dynamic, high-risk environments. A patron that was relating his escape from the fire said he observed “numerous people who were not moving and were still watching the stage” (p. 6-7).

Clearly, people enjoying the show that night did not immediately recognize they were in danger and, therefore, did not react quickly enough. When seconds were precious, many in the crowd hesitated, and this decision cost some of them their lives. By studying these types of events where people have been endangered by unexpected and dangerous circumstances, psychologists are developing theories that explain the behaviors that are common to each of us.

This research directly applies to the fire service in general and the Amarillo Fire Department (AFD) specifically. As Holgate and Clancy (2007) found, emergency service organizations have traditionally addressed the risks associated with dangerous occupations by focusing on training and demanding compliance with standard operating procedures. They found that emergency response agencies seldom account for the fact that situational awareness and perception of risk, and thus, decision-making, among their personnel will vary greatly.

For the fire service, this lack of understanding of how firefighters make decisions in stressful, life-threatening conditions can lead to inappropriate survival training. As Putnam (1995) stated, the fire service must give firefighters "a better understanding of how stress, fear, and panic combine to erode rational thinking" (p. 54).

The purpose of this applied research project will be to evaluate decision-making processes that are to be expected when firefighters confront high-risk environments. This information can then be incorporated into firefighters' survival training to give them a better chance of escaping these emergencies. Descriptive research will be utilized to answer four questions that are pertinent to understanding the impact of decision-making in critical and intense situations. To begin with, what decision-making processes do people employ when they are in dynamic, high-risk environments? Specific to the fire service, is there a relationship between the decision-making processes of the general population and those of firefighters in

dynamic environments? Additionally, what aspects of decision-making, if any, are specifically associated with fire service personnel? Finally, and of vital importance, do decision-making processes impact firefighter injuries and fatalities?

Background and Significance

The City of Amarillo is the major city of the rural Texas Panhandle. The City's estimated population of 185,500 makes it, by a factor of ten, the largest city in the region (U.S. Census Bureau, 2006). Amarillo was founded in the late 1880s as a result of the Fort Worth and Denver, Rock Island, and Santa Fe Railroads meeting at a single location as they followed natural land routes through the High Plains. This convergence of the railroads made Amarillo the center of commerce and culture for the region (Texas State Historical Association, 2002). Cattle and farming, as would be expected, were the basis for the settlement and growth of Amarillo and the Panhandle. These industries remain two of the three major elements of the local economy. The third component of the present day economy is the production of petroleum, which has been a major contributor since the 1920s.

The AFD is a 231-member career department protecting the City of Amarillo. The AFD is responsible for providing response to emergency incidents involving fire suppression, basic life support, hazardous materials mitigation, technical rescue, and aircraft rescue and firefighting. During 2005 and 2006, the AFD averaged 11,500 calls per year (Amarillo Fire Department [AFD], 2007a). This entailed dispatching 17,800 emergency response units to these incidents each year. The majority of these incidents (64%) were medical emergencies where crews provided basic life support. Over the same two-year period, the AFD responded to 785 structure fires, an average of a structure fire every day (p. 101).

An important aspect of being the largest fire department in the area is the support the AFD provides on a regional basis. Implementation of the National Incident Management System (NIMS) has led to mutual aid agreements between the City of Amarillo and the 26 counties and 67 communities in the Panhandle (Panhandle Regional Planning Commission, 2007). These agreements have committed the AFD to assist when jurisdictional assets are inadequate to meet a local emergency.

During 2005 and 2006, the AFD made nearly 200 mutual aid responses to outlying communities (AFD, 2007a). Most notably, the AFD provided technical rescue assistance when a tornado hit the small town of Cactus, Texas in the spring of 2007 and firefighting aid during the 2006 *East Amarillo Complex Fire* that burned over three-quarters of a million acres – in the first 24 hours. The AFD has an undeniable impact on the welfare of citizens throughout the Texas Panhandle.

This research will be beneficial to firefighters working for the AFD. Twice in the last two years, AFD firefighters have been exposed to extraordinary emergencies that required firefighters to call for assistance (AFD, 2006, 2007b). All four firefighters involved escaped their situations, fortunately, without significant injury. The first incident occurred when three firefighters became lost in a two-story residence heavily involved by fire. The second incident required a company officer to declare a mayday when one of his firefighters was incapacitated by an electrical shock.

This research will directly impact the survivability of AFD personnel experiencing these types of perilous events. Firefighters will have a more complete understanding of their personal psychological processes and be better prepared to react properly during life-or-death situations.

As the author was conducting this research into human behavior that focused on *situational awareness* (SA) and decision-making, the AFD was involved in two separate vehicle accidents that demonstrated the need to better understand this facet of psychology. In December of 2007, the AFD responded to a 121-vehicle accident that occurred in a blinding snowstorm (AFD, 2007c). The third AFD apparatus on scene struck one of the cars that had already been involved in the pile-up, despite the driver and officer knowing that the weather was causing intermittent zero-visibility conditions and that they was approaching the accident scene.

A month later, while en route to a 54-vehicle accident in nearly the same location and under the same blowing-snow conditions, the first arriving fire truck, after striking an involved vehicle, rolled and ended upside down in a ditch (AFD, 2008). This accident occurred even after all AFD officers had participated in a critique of the first accident, which included dramatic radio traffic that stressed the need for extreme caution during emergency response in foul weather conditions. These two incidents highlight the safety benefits that the AFD will gain as administrative and training staffs incorporate the research findings into departmental procedures and training.

The AFD has mutual aid agreements with four area fire departments, which often adopt AFD standard operating procedures (SOPs). These departments, in turn, have agreements with fire departments bordering the opposite sides of their jurisdictions. In addition, the City of Amarillo also has regional mutual aid agreements with each of the other cities and counties within the Texas Panhandle. Thus, any findings incorporated into AFD procedures will have a rippling effect that will help protect firefighters throughout the Panhandle.

This research will also aid the fire service on a national level. As the U.S. Fire Administration (USFA) (2007, p. 15) reports, the majority of firefighter injuries and fatalities

consistently occur on the fireground. This research project, as a resource available through the National Fire Academy (NFA), will facilitate the ability of firefighters nationwide to recognize and properly react when imperiled by extraordinary fire conditions. Since this research will help "reduce the loss of life from fire of firefighters" (USFA, 2003, p. II-2), it also supports the third of the five prime operational objectives of the U.S. Fire Administration.

This applied research project is, in addition, applicable to the goals of Executive Leadership (EL), the final course in the Executive Fire Officer Program (EFOP). A major aspect of the course is to influence others using techniques of successful leaders (USFA, 2005, p. v) The author's development of expertise on the subject will create a foundation of influence based on *expert power* (p. SM 9-6). The ability to persuade members of the AFD, local fire departments, and the national fire service to accept the findings and recommendations of this research will be a direct result of knowledge gained in the EL course.

Finally, the author has a deep, personal interest on the topic of firefighters recognizing and reacting to life-threatening events, and this interest is a major reason for selecting the subject of this final EFOP paper. This research expands upon findings the author identified in a research paper that compared the AFD's mayday guidelines to fire service standards (Lusk, 2005). The previous research project identified several danger recognition and reaction theories (p. 22) that were not found in the reviewed fire service literature on maydays.

Literature Review

It is well understood that firefighters must continually make life-or-death decisions for the citizens they serve. The basis for these decisions is the concept of risk management. In the fire service this means that a firefighter's life will not be risked for anything other than saving a victim's life (Hawkins & McFadden, 2003).

However, the intricacies of firefighters personally setting risk management levels for themselves as a situation deteriorates into a threat to their own life is not as well understood (Holgate & Clancy, 2007). A review of literature, both internal and external to the fire service, will be conducted to develop information on the subject of decision-making in highly dangerous circumstances. In addition, fire service literature will be examined to determine when decision-making is an integral factor in firefighter injuries and fatalities.

The initial step in understanding how people make decisions in dynamic situations is to examine the concept of SA. As Endsley (2006) states, “SA is the main precursor to decision making” (p. 4). The beginnings of SA, which has seen a sharp increase in attention from researchers in a variety of fields over the last decade, can be traced back to World War I, when it was noticed that a large number of enemy aircraft were being shot down by relatively few pilots (Patrick, James, Ahmed, & Halliday, 2006). According to the authors, this set the stage for the aviation industry to become an early pioneer in the study of SA.

Situational awareness is a wide-ranging concept that can be applied to many domains, circumstances, and events. In its most simplistic meaning, SA is an understanding of what is happening around the person or persons involved in the situation being considered (Endsley, 2000). More formally, Saus et al. (2006) defined SA as the “cognitive processes involved in perceiving and comprehending the meaning of a given environment” (p. S4). Dugan (2007) identified SA in the fire service as “the ability to process, review, and understand your surroundings on the fireground” (p. 50) so the crew’s assignment can be accomplished with the maximum amount of safety.

Situational Awareness is most applicable in terms of a task or goal. Endsley (2000) notes that a pilot needs to gather the pertinent information that applies to the task of safely flying the

plane, but doesn't need to know everything, for instance, the names of the co-pilot's children. Patrick et al. (2006) based their research on assessing SA by using a task-oriented approach. They felt that achieving SA was an integral element or sub-task of the overarching goal of task accomplishment. An important point these researchers make is that SA is not an attribute or psychological characteristic of the individual involved. Instead, SA is a model that helps define how and why people make decisions within the realm of their operational environment.

There are several models that try to explain the concept of SA. One of the most often cited is the *Model of SA in Dynamic Decision Making* (Endsley, 1995), which breaks SA into three major aspects: (a) Level 1 – Perception, (b) Level 2 – Comprehension, and (c) Level 3 – Projection.

In the Perception phase, this model requires that the person first physically receive cues from the environment. Once the cues are received, the Comprehension phase is activated to make sense of them. The multiple pieces of information that have been gathered must be integrated and analyzed to establish relevancy to the person's objective. At the highest level, the Projection phase, the person must determine how his or her current understanding of the situation will affect future dynamics and events that influence desired outcomes. Saus et al. (2006) use a similar concept of SA: (a) attention, (b) perception, and (c) decision making.

As Endsley's (1995) model depicts, the first step for decision makers to develop SA is to perceive the world around them. Patrick et al. (2006) recognize this perception phase as one component of the information processing system that also includes attention and comprehension. The means of extracting "structures from the surrounding by means of the senses" (Albert et al., 2005, p. 592) is done by the physical process of sensation. The reception of external information is limited to the senses of sight, sound, touch, smell, and taste.

Endsley (2000) and Klein (1998) both elaborate that the signals received from the environment may not be at the conscious level. Endsley (2000) notes that the subtle change in an aircraft's engine systems may not be overtly heard, but the pilot may have registered it at a subconscious level. Klein (1998) noted that several firefighters he interviewed had narrowly escaped building collapses or other dangers without being able to explain why they had withdrawn from the situation. Klein determined that in these cases the experienced officers' intuition, which made them feel like something was wrong, was actually a subconscious perception of danger signals in the environment.

The next step in the development of SA after perception is comprehension. Since SA requires the cognitive process of interpreting cues from the environment, it is a critical factor when a person is making decisions to accomplish an objective (Klein, 1998). Cannon-Bowers and Salas (1998) use the term *cognition* to describe the reception of information from the external environment and its subsequent internalization in the form of symbols or words (p. 320).

Endsley (2000) describes the interpretation process in terms of memory. Comprehension for an individual is "a unique product of external information acquired, working memory processes and the internal long-term memory stores activated and brought to bear on the formation of the internal representation" (p. 10).

The relationship between the internal and external activities is interdependent and cannot be separated according to Turner (2006). He finds that the process to internalize external cues continually transforms the receiver's internal mental model and, in return, the construct of the environment from which the cues originated. Patrick et al. (2006) concur, they state that the "S and the A of SA are indivisible" (p. 396).

The person attempting to comprehend the parameters of the environment must have a systematic means of gathering pertinent information. Endsley (2000) defines this "active process of seeking information from the environment" (p. 16) as *situation assessment*. In other words, situational awareness (SA) is a product of conducting a situation assessment to ascertain the current state of one's surroundings.

In their research on the paradigm of disaster survival, Prince and Davies (2007) used the term *surveillance* to identify the increased vigilance of people that were under the threat of flooding. Dugan (2007) makes it clear that the fire service should not confuse SA with *size-up*, the method firefighters use to evaluate the fire conditions in a building, the resources available, or the number of victims affected by the fire. He relates that SA involves not only gathering these facts but also understanding what the information means.

Within the goals established by the person involved, the situation assessment allows a decision maker to direct attention to specific aspects of the environment (Endsley, 2000). This attention enhances the integration of information into his or her internal mental model in order to better understand the situation at hand.

Once individuals have developed a mental model of the status of the environment, they have a basis on which to decide possible courses of action. The methods of making decisions generally fall into two categories: analytical and naturalistic. Analytical decisions are based on logic and factual information (Kowalski & Vaught, 2001). Pan, Han, Dauber, and Law (2007) identify this method as the predominant theory on how people make decisions. The analytical or rational decision process involves: (a) a search for options, (b) determination of the consequences for each option, (c) comparison and contrasting of the options, and (d) selection of the best option.

Klein (1998) notes that analytical decisions are practical for stable environments such as solving engineering problems where rational analysis can be utilized to examine each component in detail. Traditionally, under the restricted conditions of laboratory settings, researchers have studied decision makers primarily using analytical approaches to problem solving (Woll, 2002).

However, Woll (2002) and Hollnagel (2007) believe that rational analysis is not appropriate in field settings where the situation is dynamic and time-pressured, the information is inadequate, and the stakes are extremely high. Zsambok (1997) and Cannon-Bowers and Salas (1998) propose that *naturalistic decision-making* (NDM) is more appropriate. Naturalistic decision-making, according to Zsambok (1997), is the method experienced people use in time-pressured, uncertain, dynamic environments to assess their surroundings, make decisions, and take actions accordingly. There are several models that explain this concept.

After conducting studies on how fireground commanders make their decisions, Klein (1998) developed an NDM-based model of decision-making, the *Recognition-Primed Decision Model* (RPD). He found that the commanders rarely used an analytical approach to determine their best options. Instead, these decision makers seemed to intuitively know the correct action to take. With RPD, the decision maker uses past experience to recognize familiar patterns and prototypes instead of comparing options. This model explains how decision makers can quickly determine the appropriate actions to take when they are pressured by time and unable to gather all the relevant information.

There are similar theories to Klein's (1998) in the psychological literature on decision-making. Endsley (1995) refers to the *schema theory*, which states that people organize past experiences in memory packets called *schemata*. These packets of categorized information

prompt an individual to quickly recognize and react to a current situation without overloading the working memory.

Church (2007), in an article on wildland firefighting safety, refers to the schema theory. He believes that schemata, the encoded and categorized memories of similar situations, will allow an individual to recognize "trigger points" (p. 18) instead of trying to sift through a series of single experiences to make decisions. In her research on how people make decisions that involve risk, such as whether or not to go to war in Iraq, Reyna (2004) describes *fuzzy-trace theory*, a concept much like RPD, to describe how people encode representations of a problem's details and then determine reasoning principles from their stored knowledge. Hollnagel (2007) identifies the application of these information-processing shortcuts as *heuristics*, which trade thoroughness for efficiency. He defines heuristics as the strategy of reducing the cognitive load required to manage information processing and decision-making through the use of mental models.

The RPD model has been embraced by numerous disciplines to explain how people make decisions under stressful conditions. Pan et al. (2007) found civilian evacuees escaping a fire in a building (a) recognize the situation as similar to a past experience, (b) determine successful routines that had worked before, and (c) carried out the routines. Espevik, Johnsen, Eid and Thayer (2006) determined that RPD is an effective basis for submarine crewmembers to compare an ongoing tactical situation to previously experienced events, actions, and outcomes. "The decision maker focuses not on a particular problem, but uses his or her experience with similar situations to implement different solutions to a series of problems" (p. S25).

The fire service has also applied RPD models to firefighter's training to help them recognize when they are in a life-threatening situation. The student's training material for the

Calling the Mayday Course (National Fire Academy [NFA], n.d.) states that Recognition-Primed Decision-making is a system that firefighters can utilize to make decisions "based on prior situations and experiences" (p. 3).

The ultimate objective of the person gaining SA and deciding upon courses of action is performance, or the ability to carry out goals (Patrick et al., 2006). Cannon-Bowers and Salas (1998) and Patrick et al. (2006) comment that if the people involved develop adequate SA and improve their decision-making, the performance will more likely be positive. On the other hand, if the necessary or relevant awareness has not been accomplished, subsequent decisions may lead to errors and performance declination. Endsley (2000) suggests that as SA increases, so too will the probability of making good decisions and, ultimately, the chance of performing well will be increased.

Simply defining and explaining the concepts of SA and decision-making models does not "convey the intricate complexities of how people pick and choose information, weave it together and interpret it in an ongoing and ever-changing fashion as both situations and operator goal states change" (Endsley, 2000, p. 7). Patrick et al. (2006) support this assessment by explaining that the intricacies of different situations and the contexts in which they are experienced do not allow a standardization of decision-making concepts.

There are five key factors that influence a person's interpretation of the cues they are receiving from the environment: (a) stressors (Cannon-Bowers & Salas, 1998; Lopez & Marvan, 2003), (b) experience (Endsley, 2006; Klein, 1998), (c) cognitive biases (Holgate & Clancy, 2007; Pan et al., 2007), (d) *affect heuristics* (Reyna, 2004; Slovic & Peters, 2006), and (e) perception of risk (Nullmeyer, Stella, Montijo, & Harden, 2005; Wong, 2005). These researchers have found that the individuals are not simply receiving and automatically acting upon cues.

Instead, the signals are received and interpreted by a unique individual, and the resultant behaviors are a product of that individual's decision-making processes (Pan et al., 2007).

Stressors

The first of the key influences, stressors (Cannon-Bowers & Salas, 1998; Lopez & Marvan, 2003), can take many forms. Cannon-Bowers and Salas (1998) identified several stressors that appear in operational environments: (a) multiple information sources; (b) incomplete, conflicting information; (c) rapidly changing, evolving scenarios; (d) adverse physical conditions; (e) time pressure; and (f) threat (p. 19). Experts have found that this finding is valid in multiple domains. Espevik et al. (2006) state that, for submarine crews attacking an enemy, "Complex decisions must be made despite high workload, time pressure, uncertainty, and external threat" (p. S24).

Saus et al. (2006) determined that police officers must handle stress, time pressure, and workload when confronting the threat of a gunman. Nullmeyer et al. (2005) found that pilot failure to consider multiple information sources was a significant factor in Air Force helicopter accidents, or *mishaps* in the military realm. In contrast, Vaught et al. (2000) identified that the lack of information is also a critical component of stress. In their study of miner responses to underground fires, the researchers found that the miners often delayed their responses because of ambiguity and uncertainty in the information they were receiving.

Adverse physical conditions are another source of stress. In the aviation profession, adverse physiological conditions of pilots have been determined to be factors in several commercial aircraft accidents (Wiegmann & Shappell, 2001). Proulx (2003) found that evacuees in a burning building may have to make escape decisions while moving though disorienting smoke. The *U.S. Navy Diving Manual* (U.S. Department of the Navy, 2005) warns that a lost

diver may have problems with breathing air and could be confused, anxious, or in a panic. Paramedics perceiving stressful situations can expect to breathe faster, lose fine motor abilities, and develop tunnel vision (Young, 2004).

The impact that these stress inducers have on the decision maker has been defined by Klein (1998). He found that stressors (a) reduce the opportunity to gather information, (b) disrupt working memory, and (c) distract attention from the operational goals. Endsley (2000) supports the first of these findings by describing the role time plays in reducing the amount of critical information that can be considered. As a rapidly changing scenario unfolds, there are time limits on when a critical event will occur or an action must be taken.

Collyer and Malecki (1998) highlight this issue with a tragedy that occurred in the Persian Gulf in1988. The commanding officer of the USS *Vincennes*, who mistakenly shot down a civilian aircraft that he believed was attacking his ship, had only a few minutes to identify, analyze, interpret, and react to the information his personnel and battle management systems were reporting to him.

The disruption of working memory, Klein's (1998) second result of stress, is also identified by Patrick et al. (2006) as a cause for decreased performance. In their study on SA, these researchers observing nuclear plant control room teams recognized memory overload as a factor that can lead to human error under dynamic circumstances.

Finally, Klein's (1998) third finding, that stressors divert attention from the task at hand, is supported by other researchers. Kowalski and Vaught (2001) concluded that stress narrows the focus of attention for miners trying to escape a mine fire. A study of military aircraft accidents by Nullmeyer et al. (2005) found that channelized attention by fighter pilots was the most common contributing factor in F-16 and A-10 aircraft mishaps.

Experience

The second of the principle factors that affects SA and decision-making is experience (Endsley, 2006; Klein, 1998). The reason why this component is critical in naturalistic decision-making (NDM) environments is explained by Kozlowski (1998). He states that dynamic, high-risk situations require *adaptive expertise*, which "entails a deep comprehension of the conceptual structure of the problem domain" (p. 119).

The individual with adaptive expertise is able to recognize changes in the domain, reset task priorities, and modify strategies to accomplish the desired goals. One of the most striking illustrations of adaptive expertise comes from the aviation world. Helmreich (1997) describes the ability of three pilots to fly an aircraft by controlling the thrust of the engines after they had lost hydraulic control of the rudder and ailerons. The pilots were able to improvise a method of steering the plane that enabled them to save dozens of lives. The flight crew, without previous experience or training to handle this type of emergency, became adaptive experts when they were able to apply their knowledge of routine flight operations to the unexpected and immediately dangerous circumstances.

Klein (1998) declares, "Experts see the world differently. They see the things the rest of us cannot" (p. 145). The level of experience experts have allows them to detect patterns and anomalies in the environment that a novice would miss. Experience gives them the insight to take advantage of opportunities or to make improvisations. Endsley (2006) comments that experienced decision-makers have the foresight to predict the outcomes of events, as they are unfolding or even before. According to Pan et al. (2007), experience with emergency egress can significantly enhance outcomes for civilians as they evacuate a building during an emergency.

Reyna (2004) concluded that experience allows a doctor to make better diagnostic decisions when the information available cannot quantify the actual risk involved.

For fireground commanders, Klein (1998) found that experience was perhaps the most crucial element required in their world of high-stakes emergencies. But, several studies (Holgate & Clancy, 2007; Lopez & Marvan, 2003; Maiti & Bhattacherjee, 1999; Vaught et al., 2000) point out that simple years of experience do not equate to expertise in situational environments. The critical measurement is instead the variety of experiences the individual has had.

Vaught et al. (2000) found that highly trained professionals will still make mistakes in real-world scenarios. A crucial point they make is that even trained, experienced miners have rarely, if ever, had to flee an underground fire, and this impacts their ability to make the best decisions while an escape is in progress. Saus et al. (2006) explain that police officers rarely encounter violent confrontations that require a decision to use lethal or non-lethal force, but this life-or-death choice must still be made in moments despite the lack of previous experience.

Cognitive Biases

The third of the major influences that impact the decision-making process is cognitive biases (Holgate & Clancy, 2007; Pan et al., 2007). As Endsley (1995) states, “a person’s manner of characterizing a situation will determine the decision process chosen to solve a problem” (p. 39). The innumerable facets of personality and emotion that affect how people make decisions in complex, high-impact situations are beyond the scope of this research project. Instead, a representative sampling of cognitive biases will be examined. Williams (2007) identifies the five most common biases that inhibit effective assessments of situational cues as: (a) *availability*, (b) *representativeness*, (c) *anchor and adjustment*, (d) *overconfidence*, and (e) *framing* (p. 46).

Availability. Availability bias relates to how readily information relevant to the current circumstances can be recalled. Madhavan and Lacson (2006) note that many commercial aviation accidents are due to pilots not obtaining, or poorly obtaining, weather information critical to their decision to continue visual versus instrument flight in inclement weather. Pan et al. (2007) identified this phenomenon in people escaping a building during an emergency. In a room with multiple exits, most evacuees will attempt to flee by using the door from which they entered instead of one nearer.

Representativeness. Representativeness is the next bias Williams (2007) identifies as an influence on a person's ability to properly interpret environmental cues. He describes this bias as the subjective evaluation of whether a cue belongs to a certain class or process. Kowalski and Vaught (2000) found that this aspect of behavior has caused crucial delays for miners reacting to information which has an aspect of uncertainty. The miners often hesitated as they attempted to seek more accurate and complete information that would allow them to classify their situation as a true emergency.

Dillon and Tinsley (2005) conducted an experiment with mission operations personnel for a Mars rover that showed that representative bias can impact operations. They found personnel who had experienced a near-miss event would discount the negative consequences of a similar situation because they categorized the current circumstances as being survivable.

Anchor and adjustment. Williams' (2007) third cognitive bias is anchor and adjustment. This bias is illustrated by Helmreich's (1997) description of an aircraft accident in which the pilot made an initial, erroneous determination of ground speed (the anchor) and then failed to properly integrate conflicting information to increase power for take-off (the adjustment). As a result, the aircraft stalled and then crashed into a bridge over the Potomac River.

Wong (2005) identified *escalation of commitment* as a similar concern for decision makers. This concept describes the tendency of an individual to continue on a course of action because of a perceived investment made to the original decision. Wong found risk-taking strategies of teachers writing proposals for school equipment increased in correlation to their personal involvement in the program requiring the grant funds.

Overconfidence. The fourth cognitive bias that Williams (2007) identifies is overconfidence. Cohen, Freeman, and Thompson (1998) state that overconfidence "can cut thinking short before key issues have been explored, and may be one reason for unfortunate surprises or overhasty decisions" (p. 171). Lopez-Vazquez and Marvan (2003) identified two aspects of overconfidence in their study of disaster survivors. First, those that survived both man-made and natural disasters reported a sense of *illusory optimism*, which is a tendency for a person to feel they have more personal control over circumstances than they actually do. Those that survived disasters also expressed an *illusion of invulnerability* in which they believed that the situation they were experiencing would not actually cause them harm.

Overconfidence is not only found in civilian victims, but also in professionals working in various disciplines. Vaught et al. (2000) described overconfidence in miners that were attempting to escape underground fires. They reported that the miners would attempt to conserve their air supply by removing the mouthpieces of their breathing equipment when they encountered smoke that was less dense, believing that it was less harmful than thicker smoke.

Dillon and Tinsley (2005) concluded that near-miss events can result in the adoption of "inappropriate feelings of invincibility and control" (p. 29) for Mars rover mission controllers. Goh and Wiegmann (2001) found commercial aviation pilots made errors in risk perception

during simulation training because they were overconfident in their flight skills and had a reduced sense of vulnerability to weather and pilot error.

Framing. The fifth and final bias that Williams (2007) identifies is framing. This concept of human behavior asserts that an individual will base decisions using possible gains and losses as a reference point. For a risky capital venture, for instance, a positive frame would be the possible increase in wealth, whereas a negative frame would be amount of investment money that could be lost.

This framing effect is also valid for decisions made in terms of protecting or saving lives. Wiegmann and Shappell (2001) report that pilots feeling pressure to leave on time may be less thorough in performing preflight checks. The pilots are framing their disregard of this critical safety procedure in terms of gains and losses, the benefit of departing on time versus the chances of a catastrophic systems failure. Nullmeyer et al. (2005) found that complacency, a framing bias that reflects an individual's attitude toward hazard and risk, was a major or contributing factor in seven of the nine mishaps involving C-130 aircraft that they studied. In circumstances such as these, the framing effect can lead to the manipulation of cues or goal states to fit the chosen frame (Klein, 2007).

Another aspect of framing is that of *expectations* (Endsley, 2000). These preconceptions, whether in the form of experience, instructions, or incoming communications, will impact a person's incorporation of signals into the ongoing development of their mental model. Hollnagel (2007) explains that an anticipation of events allows the decision maker to take action quickly, without the need to commit limited attention or overload working memory.

However, the prediction and resulting actions may sometimes be inaccurate and lead to disastrous consequences. The USS *Vincennes* incident is a tragedy that illustrates this point

(Collyer & Malecki, 1998). The commanding officer, with the information available to him, expected an imminent attack by a hostile aircraft, leading him to make the decision to shoot down a harmless civilian aircraft.

Affect heuristics

Affect heuristics is the fourth key attribute that influences a person's interpretation of the cues they are receiving from the environment. Slovic and Peters (2006) explain that affect heuristics, in a manner similar to recognition-primed decision making, allows a person to quickly make decisions about a dynamic situation without resorting to detailed rational analysis. The decision maker feels the incoming stimuli are good or bad and reacts accordingly, giving emotions an important role in the decision-making process (Reyna, 2004). For instance, Drabek (1999) noted that the first feeling that most people will have to disaster warnings is that of denial.

Pan et al. (2007) further describes affect for people "perceiving a situation as highly important, highly uncertain and highly urgent. As perceived stress increases an individual may shift decision mechanisms from following experience…to following instincts" (p. 5). Affect is, thus, an intuitive, natural, and automatic influence that shapes an individual's unique decisions, despite the application of procedures or the similarity of cues that are being received (Slovic & Peters, 2006).

Madhavan and Lacson (2006) identified motivation and social pressures as affective factors that can persuade pilots to make the choice of continuing with visual flight instead of implementing instrument flight rules when they encounter bad weather. The survival manuals of the U.S. Armed Forces explain that military personnel evading capture in enemy territory will have basic and necessary reactions that act as survival mechanisms (Air Land Sea Application Center [ALSAC], 1999). The manuals list (a) fear, (b) anxiety, (c) anger and frustration, (d)

depression, (e) loneliness and boredom, and (f) guilt as psychological reactions that will affect escape decisions. These affective factors can challenge the decision-making process and lead to a decrease in performance (Slovic and Peters, 2006).

Perception of risk

Perception of risk is the last of the five key factors that contribute to the manner that a person interprets environmental signals and makes decisions (Nullmeyer et al., 2005; Wong, 2005). Wong (2005) refers to *risk perception* as the individual's assessment of the inherent risks associated with the operational environment. Each decision maker has a distinct perspective of risk that, when combined with other internal and external forces, will create a unique set of resulting behaviors (Williams, 2007). Perception of risk, as a component of decision-making, can therefore greatly affect performance outcomes. For instance, Nullmeyer et al. (2005) determined that risk assessments made by C-130 flight crews were major contributing factors in eight of the nine mishaps they analyzed.

Research shows that the same stressors, biases, and emotions that influence SA also influence risk perception. Sicard, Jouve, and Blin (2007) found that stressed, fatigued pilots showed an increased tendency toward impulsiveness that the aviators did not normally display. Kowalski and Vaught (2000) determined "subjects tended to wait until an already deteriorating situation had further deteriorated before acting" (p. 6). Horswill and McKenna (1999) reported that drivers, because of an illusion of control, were more comfortable with higher levels of risk than those that were riding with them. Slovic and Peters (2006) found that "people judge a risk not only by what they think about it but also by how they feel about it" (p. 323).

Killgore, Vo, Castro, and Hoge (2006) in a study of American soldiers, emphasize that risk perception is not the only element to consider as an influence on risk-taking behavior. In

addition to the individualistic quality of risk perception, a person's "willingness to take risks will significantly influence decision-making and its consequences" (p. 233). Wong (2005) identified this aspect of behavior as *risk propensity*, which is the individual's long-term risk-taking orientation, in terms of risk-aversion and risk-seeking.

Killgore et al. (2006) measured five factors that affect risk propensity: (a) self-control, (b) danger-seeking, (c) energy, (d) impulsiveness, and (e) invincibility. Several aspects of these factors are important. First, these researchers found that risky behaviors often correlate across several dimensions for the same individuals. As an example, a soldier who reported high-risk drinking would also tend to speed and fail to wear a seatbelt.

Killgore et al. (2006) also identified that most risk propensity characteristics remained stable throughout adulthood, the exception was related to thrill seeking (speeding) and high-energy (listening to loud music). The behaviors associated with these traits tended to decrease with age. This finding of an age related decrease in thrill seeking was also a conclusion of Sicard et al. (2007) in their study of extreme risk-taking. The researchers also found that BASE jumpers, along with commercial and military pilots, display a higher risk propensity level than the general public, with an "exception for impulsiveness scores, which is a trait considered to be undesirable in the decision making process" (p. 59).

Consideration of risk perception is essential for organizations that require their personnel to operate in dynamic, high-risk environments. Barnett and Breakwell (2001) and Holgate and Clancy (2007) determined that disagreements in tolerable risk due to individual differences in risk perception must be acknowledged and addressed. Despite the implementation of policies and procedures, violations will occur, sometimes with tragic outcomes. Wiegmann and Shappell (2001) determined that 27% of the commercial aviation accidents they examined were

attributable to violations of rules and regulations. De Graeve, Deroo, Calle, Vanhaute, and Buylaert (2003) found that Belgian ambulance drivers continued aggressive driving that violated procedures even after the installation of devices that recorded speed and braking habits.

Pressler (2008) makes two other important points about risk perception differences in an organization. First, sub-cultures may develop between authority levels because views of acceptable risk tolerances may not be in alignment. For example, managers may not always understand the inevitable contingencies that arise in the field while those performing in the hazardous environment may not comprehend the liability issues that concern management. Secondly, Pressler explains that once safety values have been set, "organizational members will defend them rather than allow them to be challenged or changed"(p.41).

Experience and training

To gain the experience necessary to develop expertise in high-impact, time-sensitive operations, there are two methods of reducing the impact of stressors, lack of experience, cognitive biases, emotions, and perception of risk (Collyer & Malecki, 1998; Klein, 1998). The first, as would be expected, is to actually work in the environment (Klein, 1998). He found that it requires multiple contacts within the field of operations to develop expertise. Klein states, "You rarely get someone to jump a skill level by teaching more facts and rules…. we cannot expect to grow instant experts" (p. 287).

Novices facing new circumstances have difficulty gathering, integrating, and understanding informational cues (Endsley, 2000). The more often the decision maker is exposed to the environment, the more it is likely that dynamic changes will be familiar to them. Sadler, Holgate, and Clancy (2007) found in their study of Australian firefighters that "career firefighters

have greater exposure to risky situations than do volunteer firefighters, thereby enhancing their cognitive skills of precarious situations" (p. 47).

Experience not only provides the decision maker with a more global understanding of the environment to determine where to focus attention (Endsley 2000), but it also gives the decision-maker a better concept of the interrelation of stressors, biases, and emotions (McLennan, Omodei, Holgate, & Wearing, 2007). Reyna (2004) concluded that experience gives a person the ability to build representations into their mental models, as well as capturing the emotional meanings within the context of the environment.

The other method of increasing experience in dynamic decision-making is through training (Espevik et al., 2006). However, for expanding decision-making skills, Cannon-Bowers and Salas (1998), Patrick et al., (2006), and Saus et al. (2006) emphasize that this training should provide more than just factual knowledge. Driskell and Johnston (1998) clarify the reason. They write that "*training* is to ensure the acquisitions of required knowledge, skills, and abilities…. *stress training* is defined as an intervention to enhance familiarity with the criterion environment and teach the skill necessary to maintain effective task performance under stress conditions" (p. 193). Kowalski and Vaught (2001) are in agreement; they recommend that a key component of simulation training for miners is the inducement of stress into scenarios to replicate field conditions.

Simulation training has been proven effective in a wide variety of disciplines as a means of developing experience for people. Simulation-based training was shown by Saus et al. (2006) to improve SA and performance, measured as hits on target in shoot and not shoot scenarios, for police cadets. Cannon-Bowers and Salas (1998) utilized simulation to enhance U.S. Navy cruiser and destroyer tactical teams' performances when they are under attack. In the aviation industry,

high-tech simulators enable pilots and crews to encounter a variety of circumstances, from inclement weather to mechanical failure, to gain experience and make better decisions when an actual emergency occurs (Helmreich, 1997; Madhavan & Lacson, 2006).

In addition to simulation training, several researchers (Holgate & Clancy, 2007; Klein, 1998; Young, 2004) recommend the specific SA and risk perception training to provide an understanding of the role these components play in the decision-making process. McLennan et al. (2007) propose that fireground commanders be given training to improve awareness of preconceptions, biases, negative emotions, and risk perception that interfere with accurate situation assessment and decision-making. Klein (1998) states that instructors, such as nurses providing on-the-job training to new personnel, should be prepared "to describe perceptual skills or to enhance the development of perceptual expertise in the trainees" (p. 173).

Holgate and Clancy (2007) propose that organizations train personnel to use the *Dynamic Cognitive Risk Assessment Model* (D-CRAM), which helps improve risk perception and promotes consistency among individuals. The D-CRAM uses a likelihood versus consequences matrix that (a) illustrates the cognitive steps of risk perception, (b) addresses possible cognitive biases, (c) and identifies risk assessment strategies (p. 1).

To enhance the safety of paramedics working at an emergency scene, Young (2004) proposes that they improve their SA by using *Awareness Progression*. This four-tiered, color-code system teaches crewmembers to consciously scan the environment and evaluate the perceived threat level. Each level has a predetermined set of parameters and actions associated with it: (a) *Condition White* means that the person is completely distracted and should consciously reevaluate their surroundings, (b) *Condition Yellow* is the basic response state in which the person is scanning the environment and can immediately identify a threat, (c)

Condition Orange creates a cautious mental state because the person has noticed or felt danger signals and should begin developing possible courses of action, and (d) *Condition Red* refers to when the individual has perceived a defined threat and must respond without delay.

Simulation training and explicit SA training are important aspects of enhancing decision-making skills in complex environments. As Endsley (1995) states, "Established doctrine, rules, procedures, checklists, and the like – though important and relevant to the decision-making process – are fairly static knowledge sources that fall outside the boundaries of the term [SA]" (p. 36).

Fire service decision-making

Examination of fire service literature identified influences that affect personnel as they make decisions in dynamic, stress-filled environments. For example, the Recognition-Primed Decision Model (RPD) (Klein, 1998), which has been previously discussed, was developed after studying the methods that fireground commanders use to manage emergency incidents. The fire service literature was reviewed to develop an understanding of decision-making processes within the fire service.

The development of SA is critical to fire service personnel as they encounter hazardous situations. Mills (2005) states that fire company officers, to be successful, must develop awareness to make their decisions by incorporating physical environmental signals and past experience. According to Dugan (2007), this "becomes even more difficult during complicated, high-stress situations" (p. 52). He recommends officers heed their intuition; the feeling that something about the fire operations is not right may be the subconscious detection of deteriorating conditions. Morris (2006) places the responsibility of SA and detecting hazardous conditions on all firefighters working on the fireground.

The National Fire Fighter Near-Miss Reporting System (NFFNMRS) (2007), a system that records and analyzes close calls that endangered firefighters, documents supporting evidence that SA development is crucial. They found that more than 90% of the near misses reported in 2006 were due, at least in part, to (a) poor decision making due to insufficient/incorrect information, (b) inadequate or incorrect perception of a situation, and (c) a lack of skill for the task (p. 11). In a special study of firefighter fatalities for the National Fire Protection Association (NFPA), Fahy (2005) cautions that firefighters must remain aware of their surroundings, recognize danger signals, and "respect them" (p. 2).

Experts in the fire service have found that the RPD model is applicable to other types of situations in addition to managing emergency incidents. Lubnau (2006) explains the RPD model is being employed when a firefighter, during the firefight, scans long-term memory until finding a pattern that matches the current circumstances. He also notes that this could cause a loss of SA if the person applies inappropriate schemata to address the current circumstances. Clark (2003), in an article that describes the relationship between RPD and mayday events, points out that life-threatening incidents are rare occurrences for firefighters. Because of this, they seldom have had a previous experience that can help diagnose the danger situation to know how to react appropriately.

Environmental stressors can interfere as fire service personnel are making decisions. Heat stress due to high-heat environments or protective clothing, heavy physical workloads, or entrapment can affect the firefighter's decision-making processes (Dodson, 2004). Experts (Clark, 2003; Dodson, 2004; Mora, 2003) have also found that disorientation in low-visibility conditions can degrade decision skills.

In a study of wildland incidents involving firefighter fatalities, Putnam (1995) makes it clear that stressors are not limited to adverse physical conditions; he adds that time-pressure and threat can also affect the decision-making process. Putnam also identified that stress can create: (a) loss of awareness, (b) loss of attention, (c) decreased memory access, (d) increased focus on task, and (e) defaults to habitual behavior.

Experience is a crucial component of decision-making during emergency incidents. Researchers (Holgate & Clancy, 2007; Klein, 1998; McLennan et al., 2007) specifically identify that experience is vital to the improvement of firefighters' performance during emergency incidents. Adaptive expertise developed through experience (Mills, 2005) and specific SA training (Lubnau, 2006) is an attribute that fire service personnel must develop for rapidly developing, complex situations. Clark (2003) recommends simulation-based training to give firefighters the mental models necessary to survive because "We cannot rely on experience to teach us this competency – the first time may be the last time" (p. 88).

One of the most dramatic examples of adaptive expertise saving a firefighter's life comes from the wildland fire service. Maclean (2004) describes the actions of a smokejumper crew supervisor as a rapidly approaching wildfire threatened him and his crew. Realizing that they could not outrun the fire, the supervisor stopped and lit a new fire in front of him. After failing to convince others to get into the burned out area with him, he laid facedown and let the main fire burn around his newly created refuge.

Thirteen of his 15 firefighters perished as the flames overtook them. The supervisor claimed he had not encountered this type of situation before. However, the sum total of his previous experiences allowed him to become an adaptive expert that knew lighting the fire was his only chance for survival.

Biases, too, can distort the decision-making processes by delaying action, creating planning fallacies, or inappropriately framing a situation (Holgate & Clancy, 2007). Close (2005) states that two firefighters who died in the *Cramer Fire* dismissed weather reports based on past inaccuracies (expectancy bias) and felt that the imminent threat would not actually harm them (overconfidence bias). Complacency, a framing bias, was complicit in the death of a firefighter overrun by fire at the *Devils Den Fire* (U.S. Department of Agriculture [USDA], 2006b) as the firefighter ignored situation assessments and radio communications that he was in imminent danger.

Clark (2003) relates an event in which biases led to inappropriate decisions. Three firefighters were hospitalized after they became disoriented while fighting a fire, ran out of air, and suffered carbon monoxide poisoning. Afterwards, one of the victims said that he had known he was in trouble, but had survived a similar situation before. The firefighter thought, " 'I found my way in; I can find my way out' " (p. 85).

The decision to self-rescue without calling for assistance exemplifies the role biases can play in a mayday event. For the hospitalized firefighter, (a) near-miss bias (Dillon & Tinsley, 2005), (b) illusory optimism (Lopez-Vazquez & Marvan, 2003), (c) overconfidence (Cohen et al., 1998), and (d) anchor and adjustment (Williams, 2007) were cognitive biases that nearly cost him his life.

Affect heuristics is another key factor impacting decisions on the fireground. Dodson (2004) describes the emotional stress that will occur when a fellow firefighter has been injured, causing crews to abandon their assigned responsibilities in order to aid in the rescue. He explains that this creates an even more dangerous environment as personnel disregard the danger signals coming from the operational environment.

The NFFNMRS (2007) found that firefighters involved in near-misses often had a misplaced motivation, “we must put the fire out because we are the fire department” (p. 12). The USDA (2006a) found that the deaths of five firefighters at the *Esperanza Fire* were caused in part by “excessive motivation to achieve assignment” and “acquiescence to social pressure (from organization or peers) to operate in hazardous situation” (p. 83).

Firefighter perception of risk is another factor that can cause decision-making errors. Lubnau (2006) points out that when firefighters lose SA, the true issue is that reality and the perception of reality have become disconnected. He states that channelized attention sets the stage for sudden, often catastrophic changes in the operational environment. For the emergencies that he studied, these changes most often involved: (a) structural collapse, (b) equipment failure, (c) electricity, (d) underestimation of fire behavior, and (e) explosion.

For fire service near-misses, NFFNMRS (2007) found that the perceptual errors of underestimating or misinterpreting critical incident factors often contributed to the incident. To counter these risk perception concerns, Morris (2006) encourages crewmembers who sense a problem to take a few moments to analyze the risk as well as share the information with others to prevent injuries from occurring.

Risk perception while driving emergency response vehicles is also a contributing factor to firefighter injuries and fatalities (Fahy, LeBlanc, & Molis, 2007). These researchers point out that road crashes are consistently the second leading cause of firefighter fatalities after heart attacks each year. For those involved, the consequences of poor risk perception are often deadly. Fahy et al. determined, “obeying traffic laws, using seat belts, driving sober and controlling driving speeds would prevent most of the firefighter fatalities in road crashes each year…” (p. 6).

Barnes (1996) points out that firefighters express their risk propensity in the form of socially acceptable risk-taking. The findings of Soane and Chmiel (2005) found that people will knowingly take risks because they are seeking a benefit, such as public respect in the case of firefighters. As Crawford (2007) points out, the term *firefighter* in America is nearly synonymous with *hero*.

Crawford (2007) believes that this image can lead to firefighters taking inappropriate risks. “The indoctrination of the word [hero] into firefighter culture appears to play into firefighters’ decision-making when they are at or en route to an emergency scene” (p. 44). He believes that this facet of fire service culture promotes the *firefighter duty-to-die syndrome* (FDTDS). Crawford states the syndrome includes the belief that there is an honorable, rewarding element to being injured or killed in the line of duty. Similarly, Bowman (2007) and Kreis (2003) have found that many firefighters that are in mayday situations will hesitate to call for assistance when in trouble. Crawford (2007) suggests that situations like this create a sense of failure that does not coincide with the firefighter’s personal image as a hero.

Another aspect of risk perception for the fire service, as has been determined in other disciplines (De Graeve et al., 2003; Wiegmann and Shappell, 2001), is that firefighters will ignore safety procedures. Close (2005) reported an investigation revealed indications that the firefighters who died in the *Cramer Fire* consciously disregarded safety rules. A National Institute for Occupational Safety and Health (NIOSH) (2006) fatality investigation determined that a firefighter in Texas, who was not wearing a seat belt, fell out of an enclosed-cab fire engine despite the fire department’s strict seat belt policy and procedures.

Compounding this issue of policy infraction is a finding of Liao, Arvey, Butler, and Nutting (2001). These researchers discovered that “firefighters who tend to ignore safety rules

and regulations not only had accidents more frequently but also suffered more severe injuries" (p. 240).

Literature Review Summary

The literature review uncovered the magnitude of the psychology involved when people operate in complex, high-risk environments. However, the review also narrowed the scope of the research. It pointed to a framework on which to conduct original research on the process of decision-making in these situations: the Situational Awareness and Decision-Making Survey (Appendix A) and the Situational Awareness and Decision Making Interview Questions (Appendix B).

The research identified a distinction between SA, decision-making, and performance, which clarified the more general topic of human behavior in emergency situations. In addition, the identification of the differences in biases and risk perception for firefighters in general and for each individual specifically was of particular importance. These differences stressed the need for the research to focus on the various personal perceptions of AFD personnel to better understand how they will react when the situation goes beyond the normal operating parameters of emergency response and becomes a threat to their life. As Barnes (1996) states, "To assume that firefighters behave recklessly merely because such behavior matches their personality profile is simplistic and foolish" (p. 2).

Two unexpected results of the literature review were discovered. The first was that an examination of structural firefighting injury and fatality reports found very few investigations that identified contributing human behaviors. For instance, a review of NIOSH fatality investigations (2008) of the 11 traumatic firefighter fatalities that occurred in Texas between 2002 and 2006 did not identify any errors that were directly attributed to risk perception or

cognitive bias errors. Crawford (2007) also noted the lack of contributing human behaviors in NIOSH reports, which he points out in his article on FDTDS.

In contrast, the wildland investigations (Close, 2005; Putnam, 2005; USDA, 2006a, 2006b) reviewed utilized checklists to specifically address the human behaviors that contributed to the fatality. This imbalance of available information weighted specific examples of contributing factors in the fire service fatalities toward the wildland community.

The other unexpected aspect of the review was that the author found very little research in the psychological literature regarding the personality characteristics of firefighters. Leckband (2005) corroborates this finding in her doctorial dissertation. She states, “the research on normal aspects of personality and occupational fit in the occupation of firefighter is limited” (p.52). Even within the fire service literature, much of the information was anecdotal in nature and not a result of study or research. This lack of research material did not allow a rich development of the relationship between decision-making processes and firefighter personality profiles.

Procedures

Several techniques were used to conduct the research for this project. These techniques included: (a) the identification of four research questions that focused the scope of the research; (b) a review of literature on the research topic; (c) a nine-question survey, and (d) four interviews with firefighters who had experienced a mayday-type event. These tools applied descriptive methodology to meet the purpose of this research project, which was to assess the decision-making processes of firefighters in dynamic, high-risk environments.

The initial step in the procedures was to identify the research questions that would narrow the focus of the research to the pertinent aspects of the subject matter. The design of the questions was intended to determine: (a) the decision-making processes that individuals use in

formulating responses to dynamic, stressful conditions; (b) whether or not firefighters are unique in their decision-making processes in these environments; and (c) if firefighter injuries and fatalities are related to decision-making processes.

The next procedural step was to conduct a literature review that examined the nature of decision-making and the elements that are involved in the process. The material studied included writings in the field of psychology and human behavior, fire service articles, and firefighter injury and fatality reports. This literature consisted of books, articles, research papers, and investigative reports.

An important finding was that there are seminal works in the field of psychology that form a foundation for other researchers to build on. Definitive books or psychology papers on the subject of decision-making in dynamic, high-risk environments were included in the literature review even though they were originally published up to13 years ago.

The element of the review that examined the psychological aspects of decision-making was especially critical to answering research question 1. It also aided in structuring the original research that, in conjunction with the literature review, helped answer research questions 2, 3, and 4. The literary research on firefighter injuries and fatalities was essential to answering question 4, and assisted in answering questions 2 and 3.

Original research for the project included a questionnaire-type survey of AFD personnel (Appendix A). The survey was conducted to help answer research questions 2, 3, and 4. The function of the first three survey questions was to develop demographic profiles of the respondents that would identify their experience in the fire service.

The next question and its associated sub-questions (Appendix A) were designed to determine the nature, severity, and risk management levels associated with significant injuries

the respondents had suffered during emergency response and operations, i.e., the dynamic, high-risk environments which are the focus of the research paper. *Significant injuries* were identified as those that had caused the firefighter to be placed on light-duty or miss work. This level of injury was used in the assumption that the respondent would more likely recall the details of the incident when the injury occurred.

The purpose of the survey's fifth question and its sub-questions (Appendix A) was to identify near-miss incidents and the types of emergencies with which they were associated. Again, in order to elicit better recall, the respondent was asked to identify circumstances that could have caused a significant injury. The next survey question was designed to determine the perception of risk respondents held regarding the injury(s) or near-miss(es) reported in the previous two questions.

Finally, the last three questions were included to help assess the SA, risk perception, and decision-making processes of AFD firefighters (Appendix A). These questions were based on the literature review. The *contributing factors* listed as possible choices in survey question 7 were taken directly from NFFNMRS (2008). The 23 *contributing stressors and biases* choices of survey question 8 were developed from information found in the literature review of psychological materials on decision-making.

The final question of the survey was designed to elicit the respondent's views on risk pertaining to the job of firefighting. The intent of having an open-ended question was to allow the firefighters to present personal perceptions of risk without any restrictions.

The survey population consisted of the 231 uniformed members of the AFD. This group was selected to identify SA and decision-making issues that are particularly relevant to the AFD. The population included all personnel that have emergency response duties, which range in rank

from firefighter to the fire chief. The survey (Appendix A) was sent to each of the ten AFD fire stations and Fire Administration on February 20, 2008, with a deadline for returning the survey set for February 27, 2008. There were 173 completed surveys returned by the deadline, a response rate of 75%.

The SA and Decision-making Survey (Appendix A) has several limitations. First, the respondents were all AFD personnel. The responses of the firefighters are therefore reflections of the safety culture of a single fire department, the AFD. It is likely that the responses of personnel in other fire departments and non-fire emergency response agencies would be different than those identified in this survey. Secondly, the survey was limited in scope. Specifically, the questions were restricted to incidents involving emergency response and operations, but a firefighter performing routine duties at the fire station must still maintain SA and make proper decisions to avoid injury. Another limitation is that the firefighters did not always understand either the questions or the intended nature of the survey. For instance, several of the respondents identified injuries they had suffered while working at non-emergency tasks.

Another concern is that the accuracy of the respondents' answers cannot be validated. The firefighter may not have recalled an incident that could have been pertinent to the research. Finally, respondents may not have answered questions accurately because they felt that a response showing safety procedures had been violated would be self-incriminating, despite the promise of anonymity.

The final research technique used was interviews conducted with personnel who were involved with two mayday-type events that the AFD had experienced in the last two years (AFD, 2006, 2007b). The purpose of these interviews was to develop original research to help answer research questions 2, 3, and 4. The interviewees were selected because they were directly

involved in these life-threatening situations, either as the victim or a supervisor in charge of the victim at the time.

Six interview questions (Appendix B) were developed to elicit responses from the interviewees regarding their situational awareness and decision-making when the incident took place. The first two interview questions were designed to determine the nature of the emergency response operations prior to the incident in question. The intent of the remaining four questions was to examine the SA, risk perception, and decision-making processes of the four firefighters during the event. Interview questions 4 and 5 were the same as the SA and Decision-making Survey questions 7 and 8 (Appendix A).

The first interview was conducted with Captain Keith Upchurch on March 2, 2008. This interview was conducted at Fire Station 8, which is located at 601 S. Western Street, Amarillo, Texas. The incident that Upchurch was involved with was a two-story, single-family residence that was heavily involved in fire. Upchurch was assigned to assist the Interior Division supervisor at the time of the incident.

The next interview was conducted with Firefighter Johnny F. Gutierrez. Gutierrez was under Upchurch's supervision when they and another officer became separated from other crewmembers that had exited the building. This interview was conducted on March 2, 2008 at Fire Station 5, which is located at 3200 S. Washington, Amarillo, Texas.

The third interview was with Captain Michael W. Rhoads. Rhoads was the Interior Division supervisor in a small single-family residence when a firefighter working with him was incapacitated by an electrical shock. The final interviewee was William C. Phillips, the firefighter that was shocked while operating the nozzle during the fire attack. Both of these

interviews were conducted at Fire Station 7, located at 3618 Amarillo Boulevard East, on March 2, 2008.

Results

The decision-making processes required in dynamic, high-risk environments are different from those used in routine situations that allow time and attention to be focused on each detail of a problem (Woll, 2002). As an environment becomes more complex and the consequences of decisions become more intense, the decision-making strategies for those involved must be adapted to more efficient methods (Hollnagel, 2007; Zsambok, 1997). Naturalistic decision-making (NDM) is a more appropriate process than rational analysis for people operating in settings involving time pressures, ambiguous information, and threat (Cannon-Bowers and Salas, 1998).

Klein's Recognition-Primed Decision Model (RPD) (1998) describes the NDM processes of people that are involved in complex, high-stress situations. The model explains that a person recognizes that current circumstances are similar to a pattern or prototype in their memory and reacts accordingly. This method of decision-making trades thoroughness for efficiency (Hollnagel, 2007). However, this heuristic method is critical to performance when timeframes are compressed, information is unclear or inaccurate, and threat is imminent (Espevik et al., 2006).

The ability to develop accurate SA on which the individual will act is a vital component of the decision-making process (Saus et al., 2006). There are three phases of SA that a person will utilize to understand the cues being received from an operational environment (Endsley, 1995). The first is the physical reception of the signals. These cues can be received at either the

subconscious or conscious level (Klein, 1998). In addition, the decision-maker can actively seek information by performing a situation assessment (Endsley, 2000).

The second phase of SA is the incorporation of signals into the mental model of the person who is operating in the environment (Cannon-Bowers, 1998). This is a comprehension stage that internalizes the cues being received and develops the individual's perception of reality (Endsley, 2000). The final phase of SA is the application of the individual's personalized understanding of sensory input (Patrick et al., 2006). In this stage the decision maker's interpretation of the environment and desired goal objectives intertwine to create behaviors that lead to positive or negative performance outcomes (Espevik et al., 2006).

There are several key influences that will produce a unique interpretation of the signals being received by the decision maker. The first is environmental stressors such as: (a) information overload, inaccuracy, or incompleteness; (b) complex, evolving conditions; (c) physical adversity; (d) time pressure; and (f) threat (Cannon-Bowers, 1998). These stressors can reduce the decision maker's ability to gather critical information, disrupt memory, or distract attention (Klein, 1998).

The decision maker's experience within the operational domain is another influence that will shape performance when the conditions are intense (Klein, 1998). To become an adaptive expert functioning at an optimal level in complex scenarios, the individual must have a diversity of experiences that has created a variety of mental representations (Kozlowski, 1998). These schemata become the foundation that the decision-maker uses to operate effectively in rapidly evolving, high-impact situations.

Cognitive biases can distort the environmental cues the decision maker is receiving (Holgate & Clancy, 2007). Five of the most common cognitive biases are: (a) availability, (b)

representativeness, (c) anchor and adjustment, (d) overconfidence, and (e) framing (Williams, 2007, p. 46). Each of these biases has been shown to cause suboptimal performance in a variety of disciplines: such as the aviation industry (Helmreich, 1997), mining (Vaught et al., 2000), and naval warfare (Collyer & Malecki, 1998).

Another key influence is affect heuristics, or the emotional component of the decision-making process (Slovic & Peters, 2006). Affect can take the form of basic emotional responses, like anger, anxiety, fear, or denial (ALSAC, 1999). Affect can also stem from higher emotional concerns, such as motivation or social pressure (Madhavan & Lacson, 2006).

The final key factor that personalizes the interpretation of environmental signals is perception of risk (Nullmeyer et al., 2005). Risk perception can be affected by the same stressors, biases, and emotions as SA, and it is highly subjective (Sicard et al., 2007).

An individual's perception of risk can be a reflection of their propensity toward risk (Wong, 2005) or it can be a product of the immediate circumstances of their surroundings (Horswill & McKenna, 1999). The differences in risk perception for individuals are of special concern for organizations where people operate in hazardous work environments. Variances of what constitutes a tolerable risk among personnel can lead to safety rule violations (Wiegmann & Shappell, 2001) or safety policy disconnects between organizational levels (Pressler, 2008).

There are two alternatives available to increase decision-making performance in dynamic, complex situations. The first is to gain experience in the operational environment by working in it (Holgate & Clancy, 2007). The greater the variety of experiences within the context of the working conditions, the greater the chance of optimal performance (Endsley, 2000). Supervisors that are mentoring or training novices should themselves be trained to provide both

knowledge and the awareness skills that are required to become adaptive experts in the discipline (Hollnagel, 2007; Klein, 1998).

The second alternative to increase decision-making performance is through training (Saus et al., 2006). This training should include both simulation training (Patrick et al., 2006) and SA-specific training (Holgate & Clancy, 2007; Young, 2004). Simulation training, or stress training, places the student in an environment that closely resembles that of the operational arena to provide an overarching perception of how situational complexities, stressors, and biases interact to interfere with the decision-making processes (Driskell & Johnston, 1998).

Situational awareness training is another method to improve performance levels in high-stress situations (McLennan et al., 2007). The Dynamic Cognitive Risk Assessment Model (Holgate & Clancy, 2007) and Awareness Progression (Young, 2004) are two specific examples being used by emergency service providers.

The research conducted showed a positive correlation between decision-making processes in dynamic, high-risk environments for the general population and for firefighters. Neither the literature review nor the original research found a single component or influential factor of the decision-making process that was applicable to the general public that did not apply to fire service personnel also.

Surveys

The Situational Awareness and Decision-making Survey (Appendix A) captured information regarding AFD firefighters': (a) demographics, (b) significant injuries during emergency response and operations, (c) near-misses during emergency response and operations, (d) stressors and cognitive biases, and (e) risk perception.

The first three questions of the response survey identified the demographic profile of the respondents (Appendix A). Table 1 details the age, years of service, and rank distribution of the 173 AFD firefighters that returned the surveys.

Table 1

Survey Results: Respondent Demographics

Survey Questions	Survey Responses						
1. Years of Age	19-25	26-30	31-35	36-40	41-45	46-50	51+
	3 %	18%	19%	12%	16%	17%	15%
2. Years of Service	0-5	6-10	11-15	16-20	21-25	26-30	31+
	18%	23%	14%	18%	12%	10%	4%
3. AFD Rank	Firefighter	Fire Driver		Company Officer		Staff Officer	
	47%	27%		20%		6%	

Note. Survey responses may not total 100% due to rounding in calculations

The survey results found a very balanced age distribution among the respondents. With the exception of the youngest group, the age range only varied by 5%. The *years of service* category did display a more uneven distribution than did the *years of age*. There was a sharp decline starting after the 20th year, which is the minimum service time required for an AFD firefighter to draw a full pension. The third question of the survey asked which position the respondent held with the fire department (Appendix A). It is an assumption that the results reflect the rank structures of similar career, civil service fire departments.

The fourth question of the response survey asked if the firefighter had suffered a moderate or serious injury “while responding to or working at an emergency incident” (Appendix A). The three sub-questions requested that the injured respondent elaborate on (a) the

type of emergency incident, (b) the severity of the injury, and (c) the property or life risk involved at the time of injury. The responses to these questions are presented in Table 2.

Table 2

Survey Results: Injuries During Emergency Response and Operations

Survey Questions	Survey Responses			
4a. Significant Injury[a]	Yes	No		
	41	132		
4b. Emergency Type	Firefighting	Responding	Non-Fire	Training
	33	2	14	1
4c. Injury[b] Severity	Moderate[b]	Severe[c]	Extreme[d]	DNA[e]
	42	3	4	1
4d. Risk Management Level	No Risk	Property	Life Safety	DNA[e]
	24	16	9	1

[a]*Significant injury*: Defined as injury that caused light-duty assignment or lost time. [b]*Moderate injury*: caused light-duty assignment or less than 1 month of lost time. [c]*Severe injury*: caused 1-3 months of lost time. [d]*Extreme injury*: caused more than 3 months of lost time. [e]Did not answer.

Of the 173 respondents, 41 reported sustaining a *significant injury* (24%). Several of these firefighters reported having more than one such injury in their career. The total number of injuries the 41 respondents reported was 50. The majority of these injuries (33) occurred on the fireground (66%), and 14 happened at non-fire emergencies (29%). Two injuries were reported to have occurred while the firefighters were responding to an emergency and one reported being injured during fire training evolutions.

In the *injury severity* category, 42, or 86%, of the reported injuries were *moderate*, which

meant that the injury had caused light-duty assignment or less than one month of lost time. Of the remaining seven injuries, three were *severe* (1-3 months of lost time) and four were *extreme* (more than 3 months of lost time). The life or property risk at the time of the injury was reported to be: (a) *no risk* 24 times (49%), (b) *property* 16 times (33%), and *life safety* 9 times (18%).

The fifth question of the survey asked the AFD firefighters to identify the number of times they had "experienced a near-miss incident that you believe could have resulted in a moderate or extreme injury" (Appendix A). The sub-question asked the nature of the emergency incident when the near-miss had occurred. The results for this question are shown in Table 3.

Table 3

Survey Results: Near-Misses During Emergency Response and Operations

Survey Questions	Survey Responses			
	Yes	No	DNR[a]	DNA[b]
5a. Reported a Near-Miss	86	68	13	6
5b. Emergency Type	Firefighting	Responding	Non-Fire	Training
	70	50	25	2

[a]Do not recall. [b]Did not answer.

There is an important point to be considered regarding the 147 reported near-miss occurrences. The survey (Appendix A) did not determine if different respondents were reporting the same near-miss incident. This may have caused the reported number of close calls to appear to be more than the number that actually occurred.

Question 6 of the survey (Appendix A) requested the respondents who answered that they had suffered a *significant injury* or had been involved in a near-miss, or both, to identify the appropriateness of initiating a mayday (a request for assistance) for their event. Table 4

categorizes the answers given for this question.

Of the 42 significant injuries reported by AFD firefighters, 39 of them were qualified as not requiring a mayday initiation (93%). Three injuries were associated with incidents where a mayday had been called. No respondent felt that a mayday was appropriate but had not been called when they had been injured.

Table 4

Survey Results: Mayday Initiations

Survey Question 6	Survey Responses	
	Injuries	Near-Miss
Mayday was Initiated	3	3
Mayday was Not Appropriate	39	130
Mayday was Appropriate but Not Initiated	-	16

Note. Six survey respondents did not answer this question after reporting an injury or a near-miss.

For the 149 near-miss occurrences where the respondent identified the appropriateness of a mayday initiation, the respondents believe that 130 of them did not require a mayday (87%). Three of those with near-misses reported a mayday was called when it was appropriate (2%). There were 16 times when the firefighter who was involved in a near-miss incident felt that a mayday should have been initiated but was not (11%).

Question 7 of the survey (Appendix A) asked for the respondents' opinions about contributing operational factors that may have been involved in the injury or near-miss event that they reported. The responses to this question are charted in Appendix C. The three most common issues that the firefighters selected were: (a) *human error* (34 times), (b) *situational awareness*

(32 times), and (c) *other* (26 times). The format of the survey did not provide a place where the respondent could explain their selection of *other*; therefore, that information was not captured.

The next question asked the AFD firefighter to identify stressors and biases that may have involved for situations where they had operated at or near the limits of safety standards (Appendix A). The answers to survey question 8 are charted in Appendix D. The four leading stressors and biases chosen by the respondents were: (a) *channelized attention* (73 times), (b) *life safety risk* (50 times), (c) *in control of situation* (50 times), and (d) *following orders* (50 times).

The final, open-ended question of the survey allowed the firefighters to identify their personal perception of risk (Appendix A). The survey responses, after they were analyzed, were categorized into 11 areas of risk (Appendix E). The three most common risk concerns for the respondents were: (a) *emergency incidents* (66 times), (b) *staff officers/company officers* (24 times), and (c) *situational awareness* (19 times). Thirty respondents did not answer this question.

More detailed results of research questions 7 (Appendix C), 8 (Appendix D), and 9 (Appendix E) will be reported later in this section. The findings will be discussed as they apply to the individual components of SA and decision-making.

Interviews

Original research for this project included four separate interviews with AFD firefighters who had recently experienced mayday-type events at residential structure fires. The six interview questions asked of the two company officers and two firefighters are listed in Appendix B.

The first two interviewees, Upchurch and Gutierrez, were both involved in interior firefighting operations at a two-story, single-family residence. Upchurch was supervising a crew of three firefighters, and Gutierrez was assigned to another interior crew. The following

description of events is a compilation of the answers these two interviewees gave to interview questions 1 and 6 (Appendix B).

Upchurch and Gutierrez reported that the crews were crowded in or near a small laundry area leading to the garage, where the main body of fire was located. They also reported that it was hot, visibility was limited, and they were having difficulty gaining access to the fire area. Upchurch stated that he and the other officer decided to get everyone out of the residence and reassess the attack.

The attack line was withdrawn from the area, and Upchurch said that he was physically directing firefighters to a nearby exit door. He saw the other officer and Gutierrez walking away in the smoke and decided to try and catch them. Gutierrez said that his officer had grabbed him by the airpack and told him they were exiting. A partial ceiling collapse in the area occurred somewhere in this timeframe.

Gutierrez said that when he and the officer located a floor-to-ceiling window at the rear of the home, he was able to break it out with a tool he was carrying. This was when he first became aware that Upchurch was with them. At the time they knocked out the window that led to the backyard of the house, Upchurch said that Command began calling for reports from each crew to determine if everyone was out of the building.

Upchurch reported that, because the crews had become separated and firefighters and officers were not sure if the others had found a way out, personnel were reported as missing. Upchurch felt that he knew what the confusion was, but could not get through to Command on the radio, and it was nearly a block to walk around to tell them in person. Gutierrez thought that the missing person was a firefighter that he had noticed having trouble navigating through the

kitchen earlier. Upchurch said the other interior officer became frantic at this point because he felt that one of his separated crewmembers might still have been inside.

Upchurch stated that it was eventually determined that all the other firefighters had left the residence through the original door where they had entered. The two interviewees were in agreement that they did not feel threatened during the event. Gutierrez, although disoriented in the smoke, said that he was not concerned because he had known they were moving away from the fire. Upchurch said that, since he had followed the other two so deeply to the back of house, exiting in that direction was better than trying to retrace their path through the ceiling collapse.

Upchurch commented that the decision to follow Gutierrez and the other officer was a decision point that he should have approached differently. He felt that he should have tried to catch them much more quickly so they all could have exited through the same door where they had entered. He also felt that Command should have assigned a tactical radio channel for the firefighters inside to reduce the congestion. Gutierrez did not make any comments regarding decisions made during the incident.

The next two interviewees, Rhoads and Phillips, were fighting a fire in a single-family residence when electrical lines that had fallen from the ceiling shocked and incapacitated Phillips. The interviews were conducted separately; however, their responses to interview questions 1 and 6 (Appendix B) have been combined in the following narration.

Rhoads stated that he was supervising the interior firefighting operation in a small residence. He had a thermal-imaging camera and could see his crew with it despite the heavy smoke conditions. His crew of firefighters was trying to get to the seat of the fire in the kitchen, but they had difficulty getting the attack line through the house. Phillips said that he was on his knees in heavy smoke that was within a few inches of the floor. He and his partner were

eventually just able to get enough hose to direct the hose stream around the doorway to extinguish the fire.

Once the fire was extinguished, Rhoads directed the firefighters to exit. As Phillips laid the nozzle down and started to push up off of his knees, an energized wire got tangled around his leg. Phillips said that as he was being shocked, he attempted to pull away but he could neither move nor speak. A fire officer working next to Phillips, realizing something was wrong reached for Phillips and felt the electricity through him. He yelled at Rhoads that the power needed to be cut off and again reached for Phillips.

Rhoads heard the statement about the electricity, and turned with the camera to watch what was unfolding. He said that he could see Phillips was convulsing with small tremors, but it took him a little time to actually determine what was happening. Once he understood the situation, Rhoads declared a mayday over the radio. The three other firefighters working with Rhoads were able to pull Phillips free and exit the building without any extra assistance. Phillips was able to walk out on his own and was treated on scene, but he did not work the remainder of the shift. He was fully recovered by the next day.

Rhoads stated that the decision he would change for a similar situation would be to call for assistance more quickly. He felt that, although he had called the mayday, he initially hesitated in order to try to better assess the situation. Rhoads said that, with the thermal-imaging camera, he could see the downed firefighter and those that were helping him, but he didn’t have enough information to determine the exact nature of the problem.

Phillips said that he did not lose consciousness, but could not move or ask for help because the electricity was causing him to convulse. Because of this, he felt that he did not have any decision-making capabilities other than attempting to communicate that he was in trouble.

The responses that the four interviewees gave to interview questions 2 through 5 (Appendix B) are detailed in Appendix F. These answers are included in the following discussion, along with the survey results of the *Situational Awareness and Decision-Making Survey* (Appendix A).

The fire service literature found that the theories and models that explain decision-making for those outside the fire service are also relevant in the high-risk environments where firefighters operate. The RPD model is not only applicable to managing emergency incidents (Klein, 1998), but is also valid as a decision model for firefighters operating on the fireground (Mills, 2005) or involved in a mayday event (Clark, 2003).

The development of SA is as important for firefighters (Dugan, 2007) as it is for other domains (Prince & Davies, 2007; Vaught et al., 2000). The lack of SA is a contributing factor in both fire service casualties (USDA, 2006a) and near-misses (NFFNMRS, 2007).

Original research results corroborate that the lack of SA is a contributing factor in AFD firefighter injuries and near-misses (Appendix C). The respondents reported 32 incidents in which *lack of SA* was identified as one of the factors that caused either an injury or a near-miss. This was the second leading contributor behind *human error*, which was reported for 34 incidents.

Contributing biases (Appendix D) that degrade SA were identified by AFD personnel as the leading factor in situations where they “have operated at the edge, or maybe just beyond the edge” (Appendix A). The most common biases selected were: (a) *channelized attention* (73 times), (b) *distracted* (32 times), (c) *limited by senses* (22 times), and (d) *did not perceive threat* (21 times) (Appendix D). *Channelized attention* was, by far, chosen as the bias most often associated with these hazardous situations. When the respondents reported their personal

perception of the “greatest risk of harm” (Appendix A), the single leading risk identified was *lack of SA* (Appendix E, 9b). The results of the interviews with the four firefighters involved in the two mayday-type emergencies indicate a similar pattern (Appendix F). Each of the four bias components of SA was also chosen as a contributing factor by at least one of those involved.

The five key influences on decision-making found in the psychological literature were also applicable to the fire service. These include: (a) stressors (Clark, 2003; Putnam, 2005); (b) experience (Holgate & Clancy, 2007; McLennan et al., 2007); (c) biases (Close, 2005; USDA, 2006b); (d) affect heuristics (Dodson, 2004); and (e) perception of risk (Fahy et al., 2007; Labnau, 2006).

The research results found that these decision-making influences were factors for the AFD as well (Appendix C). Survey respondents identified *human error* (34 incidents) and *decision-making* (23 incidents) as factors that contributed to the reported injury or near-miss. These were the first and third leading causes AFD personnel selected.

Physical stressors were not as common a selection as biases (Appendix D). For instance, not a single respondent chose *impaired by fumes/ smoke* as a factor. The most common adverse physical conditions chosen were *rapid change in conditions* (26 times) and *limited by senses* (22 times). These were also identified by three of the four interviewees as contributing stressors in the mayday incidents (Appendix F).

Experience issues were a common concern in the selection of contributing factors, contributing biases, and the perception of risk questions. *Decision-making* (23 incidents) was the third most common factor that contributed to the reported injuries and near-misses (Appendix C). *Command* (10 incidents) was also a contributor. As a contributing bias, *following orders* (50 times) was tied as the second most identified issue (Appendix D). Firefighters perception of

greatest risk was often *staff officer/company officers* (24 times), which was the second leading category after *emergency incidents* (66 times) (Appendix E).

The original research supported the findings of the literature review that affect biases are key aspects of firefighter self-image. AFD personnel commonly identified these issues as reasons for operating on the edge (Appendix D). They selected: (a) their job is to be an *edgeworker* (48 times); (b) they *will disregard safety SOGs* (23 times); (c) they *won't be the first to leave* (18 times); and (d) they *won't exit for potential risk* (17 times). Affect biases were a major risk concern for AFD personnel as well (Appendix E). Firefighters expressed *personal concerns* 13 times. Of these, *disability/death* (8 times) was the most common.

The three most common cognitive biases that pertain to risk perception were that the firefighter: (a) noticed a hazard but felt *in control of the situation* (50 times), (b) had *escaped similar situations* previously (28 times), and (c) *did not perceive a threat* (21 times) (Appendix D). Again, the interviewees related similar experiences; each of the three biases was selected by at least one of the firefighters (Appendix F).

For AFD firefighters, training issues were one of the least common choices as (a) *contributing factors* to injuries and near-misses (9 incidents) (Appendix C), (b) *contributing stressors and biases* to hazardous situations (7 times) (Appendix D), and *risk perception* (2 times) (Appendix E).

The literature review and original research found that each major aspect of decision-making that applied to the general population and other professions also applied to the fire service. However, the research did not definitively determine any dimensions of decision-making that were specifically associated with fire service personnel.

Firefighters will often chose to work in the fire service because society perceives their penchant for risk-taking as a positive trait (Barnes, 1996). However, this characteristic is also true of other professions, such as soldiers (Killgore et al., 2006). Firefighters are aggressive and will wait until the last possible moment to call for assistance (Bowman, 2007; Kreis, 2003). However, this is valid for both commercial aviators (Goh & Wiegmann, 2001) and military pilots (Nullmeyer et al., 2005).

There is one specifically identified decision-making concern that may be significantly more pronounced in the fire service than in other domains. Firefighters internalize the cultural image of heroic public servants willing to risk their lives to save others from harm (Crawford, 2007). This can pressure a firefighter to exceed safety standards in an attempt to fulfill the expectations of the public and of the fire service, a sense of obligation identified as the *firefighter duty-to-die syndrome*.

The research conducted supported this sense of duty among AFD personnel. When selecting choices for why they had operated in threatening situations, the firefighters chose *life safety risk* 50 times, which was tied as the second most common stressor or bias (Appendix D). They frequently chose the more affective bias options: (a) a duty to *operate on the edge* (48 times), (b) a willingness to *disregard some safety procedures* (23 times), (c) a reluctance to be *the first person to leave* (17 times), and (d) a reluctance to *withdraw from a potentially risky situation* (17 times). Only a one of the interviewees chose a contributing stressors or biases in this category (Appendix F). Phillips selected that one reason he was involved in a mayday event was because of his obligation to *operate on the edge*.

The original research did determine a positive correlation between firefighters' decision-making processes and injuries and near-misses. This supports fire service fatality investigation

reports that SA and the resultant decisions are contributing factors in fire service casualties (USDA, 2006a) and near-misses (NFFNMRS, 2007).

AFD firefighters identified 216 total *contributing factors* (Appendix C) that were attributed to their 50 reported injuries (Table 2) and 149 near-misses (Table 3). The most common issues identified were decision-based: (a) *human error* (34 times), (b) *situational awareness* (32 times) and, (c) *decision-making* (26 times) (Appendix C). This a sharp contrast to the procedural factors that were chosen, such as: (a) *teamwork* (1 time), (b) *SOPs/SOGs* (3 times), (c) *accountability* (6 times), and (d) *training* (9 times).

This is also reflected in the respondents' choices of contributing stressors and biases for situations where they were operating at or near the edge of safety (Appendix D). Again, the most common were decision-based concerns, such as noticing "there was a problem, but I felt I had control of the situation" (Appendix A), which was selected 50 times. On the other hand, stressors that did not directly apply to decision-making were much less likely to be selected as a pertinent contribution to the hazardous situation. *Impaired by fumes/smoke* was not chosen at all and, *inadequately trained* was a factor only 7 times (Appendix D).

Discussion

After having experienced a firefighter fatality in 2005 (NIOSH, 2006), two mayday events in two years (AFD, 2006, 2007b), and, even more recently, the two significant vehicle accidents in December of 2007 (AFD, 2007c) and January of 2008 (AFD, 2008), research on SA and decision-making has come at an opportune time for the AFD. Each of these incidents highlights the need for AFD firefighters to understand the concepts of risk perception, SA, and decision-making as they encounter situations that place them and others in harm's way.

Several key issues pertaining to SA and decision-making must be addressed by the AFD.

First, the simplistic view of firefighters risking their lives to save others because they are altruistic public servants (Appendix D) or they have aggressive personalities (Barnes, 1996) only touches the surface of the complexities that encompass firefighters' decisions when they are operating at an emergency scene. It is apparent from the literature review and the original research that AFD personnel are subject to multiple influences, both internal and external, that will produce individualized decisions, even with a strong set of organizational policies and procedures in place (Putnam, 1995; NIOSH, 2006).

Firefighters, the research has concluded, are subject to the same pressures, biases, and emotions as others who must perform well in intense, complicated situations (Appendix D; Fahy, 2005). The facets of decision-making that influence individuals outside the fire service also affect firefighters; these are, after all, human behaviors that pertain to individuals whatever their occupation or circumstances. It is, therefore, crucial that AFD personnel understand the basic decision-making processes that lead to either optimized or degraded performances, especially when lives depend on those performances.

For AFD command staff and company level officers, situational assessments only build a set of facts that determine the operational parameters of the emergency (Dugan, 2007). The ability to understand what those facts mean, project the possible outcomes, and react appropriately is an ability that must be nurtured and guided (Endsley, 2000). The research findings illustrate that AFD officers must be given opportunities to fully develop these talents through varied assignments and experiences (McLennan et al., 2007) and simulation-based training (Saus et al., 2006). As the research found, AFD firefighters will follow orders that place them in hazardous situations (Appendix D), and the officers that give those orders must be able to properly decide if it is appropriate to do so.

All AFD firefighters, regardless of their rank, must understand the influences that determine the decisions they will make when challenged by dynamic, high-risk environments. When they are working in zero-visibility, high heat, and lives are at stake, the consequences of their behaviors could determine who lives and who dies (Holgate & Clancy, 2007). The firefighters must be trained to be decision-making experts that can "see the world differently" (Klein, 1998, p. 145) to reduce the chances of injury due to stressors or biases, such as unexpected changes in their surroundings, channelized attention, or feelings of invulnerability (Appendix D).

Amarillo Fire Department personnel have individualistic views of risk, which are shaped by personal experiences, biases, and emotions (Appendix C; Appendix D; Holgate & Clancy, 2007). This is an important issue that greatly affects the AFD. For instance, the firefighters that answered the last question of the response survey identified 36 different risks (Appendix E) that they perceived as the "greatest risk of harm" (Appendix A). Each of these are valid concerns, yet the variety of perspectives listed can lead to personnel unnecessarily putting themselves in dangerous positions because the AFD has not standardized tolerable risks (Lubnau, 2006) beyond the risk management criterion that a firefighter's life will be placed at risk only to save a person's life (Hawkins & McFadden, 2003).

These differences in risk perception and the impact they have on decision-making is not limited to firefighting operations. The second leading cause of firefighter fatalities occurs on the road away from the actual emergency scenes (Fahy et al., 2007). This is a valid concern for the AFD. Since 2005, the Department has been involved in two major vehicle accidents (AFD 2007c, 2008) and lost a firefighter who died when he fell out of an enclosed-cab fire engine (NIOSH, 2006). The management of risk perception for fire apparatus drivers and the

crewmembers riding with them is a critical component of increasing safety for AFD personnel.

There are two findings of the original research that fire department administrators and staff must be made aware of to better manage safety concerns. The AFD has firefighters that willingly place themselves in precarious positions simply because they feel that it is part of their job (Appendix D) or they have a need to fulfill the expectations of public (Crawford, 2007). They will purposely, and with forethought, violate safety policies and procedures (Appendix D; Close, 2005). This exceptional finding is not necessarily particular to the AFD or the fire service (Wiegmann & Shappell, 2001), but it is a finding that is a concern.

Several of the responses to question 9 of the survey, which asked about risk perception (Appendix E), were vehement in their identification of staff officers or company officers having little common sense (Appendix E) when it came to safety issues. This undertone is likely occurring due to the different views of risk held by the rank and file and management levels of responsibility within the Department (Pressler, 2008). It is possible that the ongoing investigations of the two vehicle accidents (AFD 2007c, 2008) and the disciplinary actions being considered are the source of the differing viewpoints.

The findings that have determined AFD firefighters' decisions impact injuries and fatalities are the ultimate safety issue for the AFD. This is as valid for the AFD (Appendix C) as it is for the fire service in general (USDA, 2006a, 2006b). The original research will set a foundation for the AFD to build on in order to reduce the injuries and, hopefully, prevent fatalities that are the consequences of ineffective decision-making processes. The improvement in situational awareness and decision-making processes that will result from the information developed can lead to safer dynamic, high-risk environments for AFD firefighters.

Recommendations

This applied research project has established a relationship between the decision-making processes of firefighters working in or threatened by dynamic, high-risk situations and fire service injuries and fatalities. To address this issue for the Amarillo Fire Department specifically, and the fire service in general, there are four recommendations based on the research.

First, the AFD should develop a mentoring program that specifically focuses on the improvement of perception and SA skills for staff officers and company officers. The purpose of this recommendation is to improve the emergency incident management capabilities of those who are making decisions that place firefighters in harm's way. A simulation-based component with purposely induced stressors should be included as part of the program. In addition, experienced mentors that are guiding the students should be taught to relate perception and decision-making skills along with technical knowledge (Klein, 1998).

The second recommendation is for the AFD to develop a training program for all personnel that places them in multiple and varied simulations that replicate life-threatening conditions. The intent of this recommendation is to enhance the personal survival skills of each firefighter should they encounter a true life-or-death emergency. As Clark (2003) stresses, the firefighter should have past experiences, through training, that build the mental models required to recognize dangerous situations and make rapid, effective survival decisions.

It is highly recommended that the simulation training be extended beyond firefighting activities. Driving simulations that reinforce risk perception, SA, and decision-making skills should be developed and used to increase safety for responding AFD firefighters. The reason for this is to lessen the hazards associated with driving emergency apparatus, which is the second leading cause of fatalities in the fire service (Fahy et al., 2007). In addition, the two recent AFD

vehicle accidents that occurred in limited-visibility conditions (AFD, 2007c, 2008) illustrate that the AFD is not immune from the dangers involved with emergency response driving.

The research conducted has made it clear that firefighters willingly violate safety policies and procedures for altruistic purposes, such as saving another person's life (Appendix D), as well as to fulfill the cultural images of firefighters as heroes (Crawford, 2007). Therefore, the third recommendation is that the AFD adopt methods of standardizing risk assessment throughout the Department. To support this recommendation, it is further proposed that the AFD Health and Safety Officer research and test the Dynamic Cognitive Risk Assessment Model, which has been specifically developed for use by fire service personnel (Holgate & Clancy 2007).

The fourth recommendation is that the fire departments that have mutual aid agreements with the AFD be formally given access to the research materials, instruments, and results of this project. The purpose of this recommendation is twofold. The first is to standardize safety policies and procedures among the four fire departments that respond to emergency scenes together. But as the research indicates, policies and procedures are only part of the expertise required to operate in complex, high-stress environments (Endsley 1995). The second, and more important reason to share the research results is to improve the safety and wellbeing of all local firefighters.

As this research has shown, the ability to perceive, interpret, understand, and act upon environmental cues is not restricted to fire service personnel. Instead, many disciplines require adaptive experts that can manage the demands of operating at optimal performance levels when timeframes are compressed and information is ambiguous (Espevik et al., 2006).

It is important for those readers that operate in demanding, complex domains be proactive in developing the decision-making skills required to achieve optimal performance. As shown by this research, the implementation of policies or the development of step-by-step procedures will

give an individual a foundation of facts and skills, but it will not provide the ability to apply the knowledge in the face of unclear information, physical stressors, personal biases, and imminent harm (Kozlowski, 1998). The reader should always remember that the time to prepare is before the signals become distorted and unclear, and before the window of opportunity starts closing. It is recommended that the reader actively pursue training that will help develop them into experts that can work beyond routine situations, where the ability to adapt to solve new and unusual problems is the measure of success.

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Appendix A

Situational Awareness and Decision Making Survey

1. How old are you?

_____ 19-25 years
_____ 26-30 years
_____ 31-35 years
_____ 36-40 years
_____ 41-45 years
_____ 46-50 years
_____ 51 + years

2. How long have you been in the fire service?

_____ 0-5 years
_____ 6-10 years
_____ 11-15 years
_____ 16-20 years
_____ 21-25 years
_____ 26-30 years
_____ 31 + years

3. Which position do you currently hold with the Amarillo Fire Department?

_____ Firefighter
_____ Fire Driver
_____ Company Officer
_____ Staff Officer

4a. Have you, *while responding to or working at an emergency incident*, suffered an injury that required you to be placed on light-duty or to miss work?

_____ Yes
_____ No
_____ Do not recall

4b. If you answered "Yes" to question 4a, what type of emergency was involved?
If you have been injured more than once, mark the appropriate number of times for the type of emergency incident.

_____ Firefighting emergency
_____ *Responding* to an emergency incident
_____ Non-fire emergency
_____ Other (Please indicate type):_____

4c. If you answered "Yes" to question 4a, how severe was the injury?
If you have been injured more than once, mark the appropriate number of times for each level of injury that applies.

_____ Moderate (Placed on light duty or missed < 1 mo. of work)
_____ Severe (Missed 1-3 mos. of work)
_____ Extreme (Missed > 3 mos. of work)

Appendix A (cont'd)

Situational Awareness and Decision Making Survey

4d. If you answered "Yes" to question 4a, what was the level of risk to property, victims, or other firefighters *at the time of your injury*?

_____ No Property or Life Safety Risk
_____ Property Risk Only
_____ Marginal Life Safety Risk (Victim could sustain light/moderate injury)
_____ Extreme Life Safety Risk (Victim could sustain severe injury or death)

5a. *While responding to or working at an emergency incident*, have you experienced a near-miss incident that you believe could have resulted in a moderate to extreme injury to yourself or others?

_____ Yes
_____ No
_____ Do not recall

5b. If you answered "Yes" to question 5a, what type of emergency was involved? If more than one near-miss incident has occurred, mark the appropriate number of times for the type of emergency incident.

_____ Firefighting emergency
_____ *Responding* to an emergency incident
_____ Non-fire emergency
_____ Other (Please indicate type):_____

6. If you answered "Yes" to question **4a** or **5a,** was a mayday initiated? If more than one injury or near-miss applies, mark the appropriate number of times for each.

_____ Yes, for an incident involving an injury
_____ Yes, for an incident involving a near-miss event
_____ No, but emergency traffic or a mayday was *not* appropriate
_____ No, but emergency traffic or a mayday was appropriate

7. If you answered "Yes" to question **4a**, **5a**, or **6**, please indicate the contributing factors that applied to: the injury(s), the near-miss incident(s) or mayday. *Select as many as you feel apply.*

_____Accountability	_____Human Error	_____Task Allocation
_____Command	_____Individual Action	_____Teamwork
_____Communications	_____Procedures	_____Training Issue
_____Decision-making	_____Situational Awareness	_____Unknown
_____Equipment	_____SOP/SOG	_____Other
_____Fatigue	_____Staffing	

Appendix A (cont'd)

Situational Awareness and Decision Making Survey

8. As a firefighter, we are often placed in situations that make us feel that we are at the edge of our physical and mental limits, and as psychology experts recognize, there are Human Factors that play a role in perceiving risk and reacting to it.

Please recall *various emergency incidents* where you have operated at the edge, or maybe just beyond the edge, and select as many of the following factors that apply. Some questions have options, please circle these if they apply.

_____I was not aware of the danger because of the limits of my senses.
_____I had gotten out of similar situations before.
_____I believed that a person's life was at risk.
_____I was not adequately trained for the situation I encountered.
_____I did not adequately plan on the time it took to accomplish my assignment.
_____My attention was focused on completing my assignment.
_____I will complete my assigned task even if I have to disregard some safety procedures.
_____I believe it is my job as a firefighter to operate at the edge.
_____I noticed there was a problem, but I felt I had control of the situation.
_____I was committed to the plan of action I had decided on.
_____I was distracted by other conditions/information.
_____I was following orders that placed me in the situation.
_____I was not aware of the danger because I was fatigued/overheated.
_____I was not aware of the danger because I was impaired by toxic fumes/smoke.
_____I did not respond correctly to the situation as it was occurring.
_____I could not react quickly enough to match the changing conditions.
_____I did not believe the situation could harm me.
_____I do not like to withdraw from a *potentially* risky situation.
_____I was not going to be the first person to leave the situation.
_____I continued with my assignment after an equipment failure.
_____I was too complacent.
_____I could not communicate properly.
_____Other (Please identify the factor):_____

9. What do you see as the greatest risk of harm to you as a professional firefighter?

_____

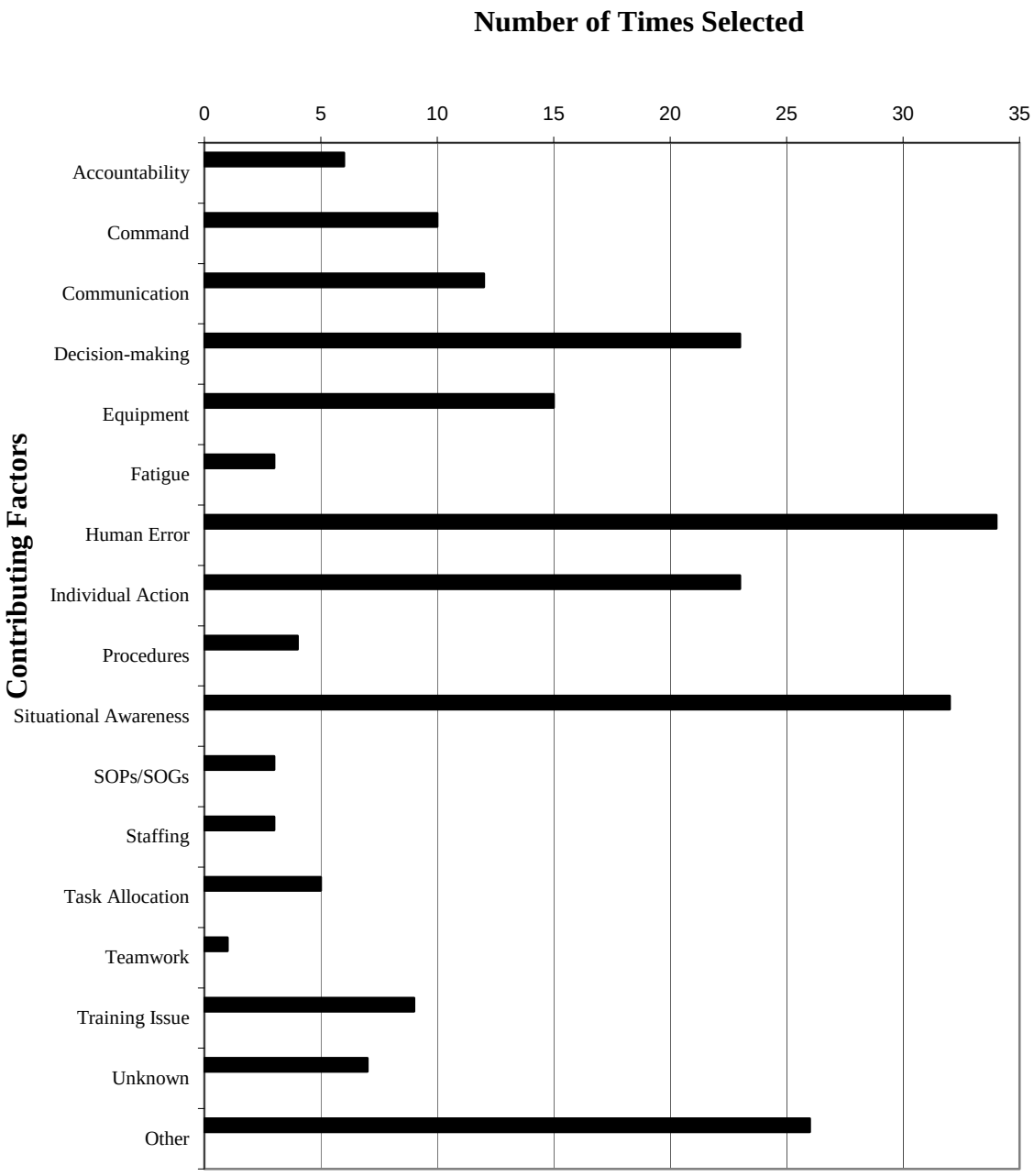
Appendix B

Situational Awareness and Decision Making Interview Questions

1. Can you briefly describe the incident where the mayday procedures were initiated?
2. What were your assigned responsibilities during the incident?
3. Until the time the mayday was announced, did you feel that the situation was beyond the range of normal firefighting activities?
4. Can you identify any factors from the Situational Awareness and Decision-Making Survey, question #7, which contributed to the mayday event?
5. Can you identify any factors from the Situational Awareness and Decision-Making Survey, question #8, which were related to the mayday event?
6. Do you have any other comments regarding situational awareness or decision-making regarding this particular incident?

Appendix C

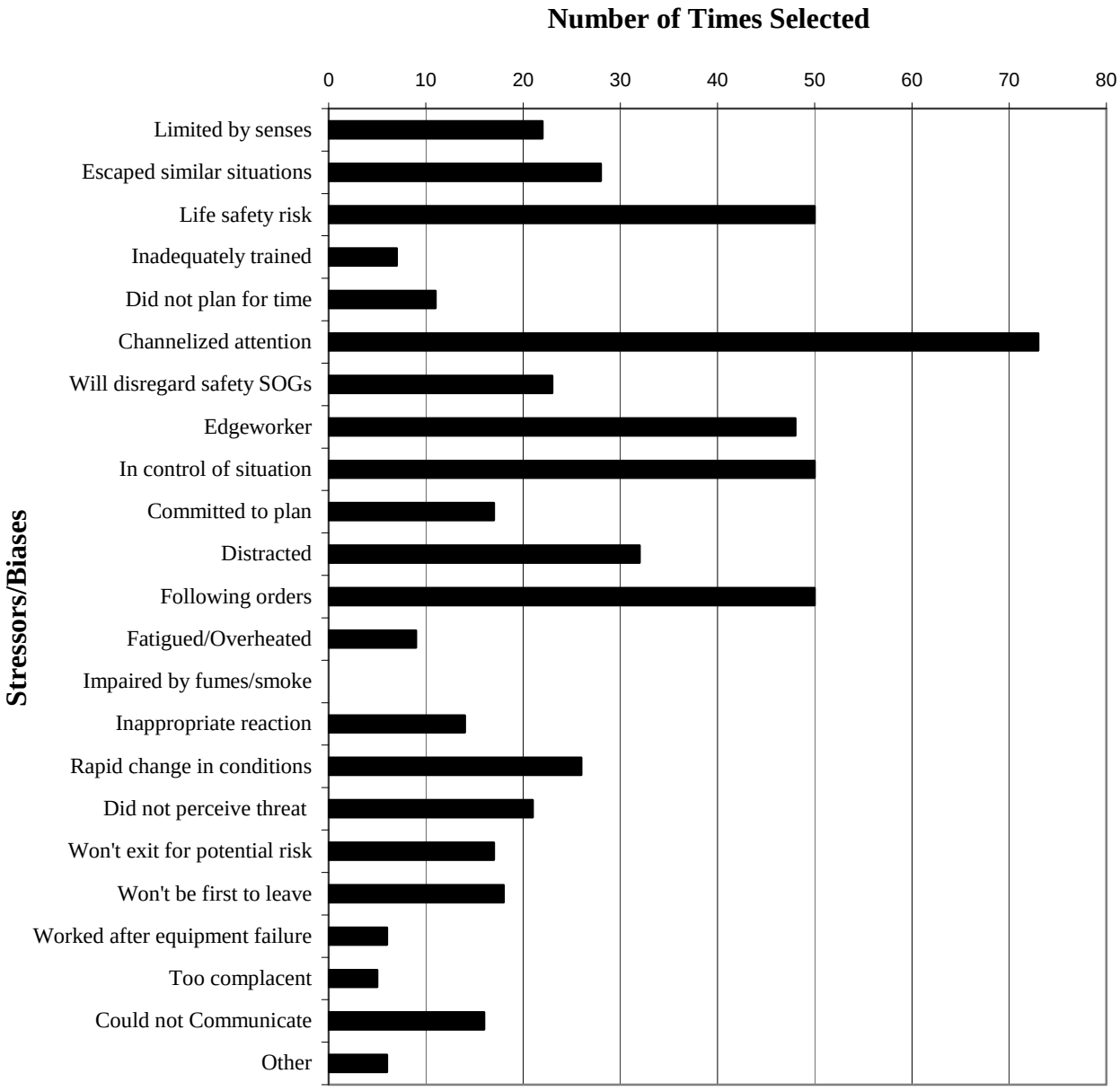
Responses: Survey Question 7 (Contributing Factors)



Note. The *Contributing Factors* were taken from the National Fire Fighter Near Miss Reporting System at http://www.firefighternearmiss.com.

Appendix D

Responses: Survey Question 8 (Contributing Stressors and Biases)



Appendix E

Responses: Survey Question 9 (Perception of Risk)

Respondent's Perception of Risk	Number of Times Identified
1. Complacency	**6**
2. Criminal Activity/violence	**2**
3. Emergency Incidents:	**66**
3a. Collapse	9
3b. Commercial Building Fires	1
3c. Communications	8
3d. Exposure to disease	7
3e. Exposure to smoke/toxic fumes	2
3f. Freelancing	1
3g. Hazardous conditions	4
3h. Inappropriate tactics	2
3i. Inexperienced firefighters	2
3j. Rapid fire change	10
3k. Weather	3
3l. Working in traffic	17
4. Emergency Response:	**18**
4a. Emergency Response	11
4b. New drivers	1
4c. Unsafe drivers - fire department	1
4d. Unsafe drivers – public	5
5. Equipment/vehicle failure	**3**
6. Personal Concerns:	**13**
6a. Disability/death	8
6b. Personal inflexibility	1
6c. Psychological impact	2
6d. Working on the edge	1
6e. Written-up for doing job	1

Appendix E (cont'd)

Responses: Survey Question 9 (Perception of Risk)

Respondent's Perception of Risk	No. of Times Identified
7. Physical Fitness	**11**
8. Policy and Procedures:	**4**
8a. Safety SOGs restrict adaptability	2
8b. Too many cause confusion	1
8c. Too many varied work responsibilities	1
9. Situational Awareness (lack of):	**19**
9a. Channelized Attention	1
9b. Situational Awareness (lack of)	18
10. Staff officers/company officers:	**24**
10a. Common sense (lack of)	11
10b. Inexperience	7
10c. Micromanagement	2
10d. Overconcern with ICS	1
10e. Pride	3
11. Training (lack of)	**2**
12. Did not answer	**30**

Appendix F

Responses: Interview Questions

Interview Questions	**Interviewees' Responses**			
	Upchurch	Gutierrez	Rhoads	Phillips
2. Assignment	Interior Supervisor	Searching for fire extension	Interior Supervisor	Operating Nozzle
3. Situational Awareness	Normal Operations	Normal Operations	Normal Operations	Normal Operations
4. Contributing factors:				
Accountability	x			
Communications	x	x	x	
Decision-making			x	
Individual actions	x		x	
Situational awareness	x			
Unknown	x			x
5. Stressors and biases:				
Limited by senses			x	x
Escaped similar situations	x		x	
Life safety risk	x			
Channelized attention				x
Edgeworker				x
Situational control			x	
Distracted	x			
Following orders				x
Rapid change in conditions	x			
Did not perceive threat			x	
Could not Communicate	x		x	